The Blast Furnace and Steel Plant

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The Blast Furnace and Steel Plant

VOL. VIII. PITTSBURGH, PA., JANUARY, 1920. No. 1.

TECHNICAL developments and advances are of intense interest and importance to the operating officials and engineers of the great iron and steel industry. The review of these advances is the chief purpose of this Annual Issue.

In order to review such a comprehensive subject in a logical manner this issue is divided into a number of departments, each representing an important phase of the industry and including one or more articles written by eminent engineers and operating officials who are thoroughly conversant with that phase of the industry. Each department also contains a description of a plant or mill typifying modern practice. Where possible future lines of development are suggested.

Inasmuch as the progress of the engineering and metallurgical problems of the industry is not as clearly defined in the course of one year as are production or cost statistics, it has been found advisable in many cases to review various subjects over a period of more than one year. In every case the review has been brought to date, so that this issue contains, as nearly as possible, a cumulation of the most modern and up-to-date engineering and metallurgical practices of the iron and steel industry.

Steel Industry Experiences Strenuous Year

Review of the Steel Industry During 1919 Shows Interesting Developments and Experiments in Prices—Influence Effecting Steel Market—Review of Strike.

By B. E. V. LUTY.

THE iron and steel industry passed through some very interesting experiences in 1919. It had a run with the momentum left by the war activity, then a slowing down to a 50 per cent production rate, with a weak market, and then the usual recovery. It had a strike, which was the experience of its life, and had just completely emerged from it when the year ended.

The post-bellum period brought new problems, chiefly of an economic character. Before the war the steel market operated on a system that was rather crude in a way but from the practical viewpoint was quite effective. There was a cycle of advancing prices, sustained prices, declining prices, stagnation and then activity, with advancing prices, etc., all over again. The market calibrated itself to zero, so to speak, in the period of stagnation, prices falling as low as any seller wanted to see them fall, and thus when they started to advance there was no doubt but that they were on the right road. Buyers and sellers joined in helping the advance along and with each step in the advance contracts were placed farther and farther ahead. When the supply of conditions favorable for advances ran out the price movement halted but production and consumption kept on, buyers being supplied by deliveries on old contracts. Mills maintained prices because there was little business to be secured by cutting prices as consumers were under contract. When the contracts were so nearly completed that there was more business to be gained by cutting prices than could be squeezed out of contracts by maintaining prices the market declined and sought out its low point. The length of the cycle from low point to low point varied. It was four and a half years from late in 1904 to early in 1909, then two and a half years to late in 1911, and then three years to 1914. A revival was then due, the great war first postponing and then accentuating the revival.

During 1919 the steel industry passed through one of the most strenuous years of its existence. With unrest evident in every industry the steel industry was the first large industry to fight a strike, which although not successful reduced the production of steel to the extent of about 3,000,000 tons. Throughout the year the industry typified a high grade industrial conscience, by voluntarily reducing costs and effectively defeating a most unjust strike.

The Steel Trade's Dilemma.

The trouble with the steel trade at the beginning of 1919 was that it didn't know whether the market was at the top or bottom. It could have run through its usual cycle true to form if it had only known where to begin, whether the existing condition represented a low point or a high point.

The steel trade, and by that term is here meant the trade that has to do with steel, some as producers and some as fabricators or consumers, had no monopoly of such uncertainty. Business in general did not know whether it was beginning or stopping. Prices had been held down by the government during the war, hence when the control was removed they would advance. Prices were so much higher than before the war that obviously they would have to come down. Everybody had been working at such feverish pace during the war that naturally they would want to relax afterwards and take things easy. So much necessary work had been left undone that everybody would want to work particularly hard in order to catch up. Wages were so high that they would have to come down. Workmen had found it so easy to get higher wages that they wanted further advances. So much capital had gone into war loans that the supply of capital for investment projects would be very limited. Money was so easy, and men had gotten into the habit of thinking in so much larger sums, that capital would be particularly easy to enlist in new ventures. The cost of living was so high that nobody had any money to spare. Incomes had so increased that everyone had a great deal more money to spend.

If a better explanation than the foregoing can be found for the fact that steel production reached its low point precisely six months after the armistice was signed, the find should be advertised for a reward. In January the production of steel ingots was at the rate of 87 per cent of capacity, rated on a conservative basis. Production declined steadily until about the middle of May and then at once began to increase, the month as a whole showing a 54 per cent rate, indicating a 50 per cent rate at about the middle of the month. August showed an 80 per cent rate, and next month the iron and steel strike came. At the end of the year the rate was between 75 and 85 per cent, accounts being somewhat confusing, while all departments were endeavoring to run full.

Experiments in Prices.

In the closing weeks of the war very serious fears had been entertained that there would be a disastrous slump in prices upon the cessation of hostilities, with much unemployment and distress. Steel being particularly a construction material, and capital being unwilling to embark in construction enterprises on the eve of a prospective decline in all values, was likely to be hit particularly hard. It was seriously proposed that the War Industries Board, which had held prices down during the war, should after the war hold prices up, even if enabling legislation by Congress were necessary. The price committee of the American Iron and Steel Institute contemplated a series of price reductions, and formulated a set of reductions for presentation to the War Industries Board. The board refused even to listen to the proposition and thereupon the list was made public, being immediately adopted, December 13, 1918, as the new market by the various steel producers. The reductions averaged about $5 a net ton on the whole list of steel products. The pig iron reduction was $3 a ton but the furnaces did not recognize the reduction until January 2, 1919.

Results were then awaited. The volume of business declined. It appeared to be a clear case of the momentum left by the war being lost gradually. The steel trade was divided. Some producers wanted lower prices so that buying would be encouraged. Others wanted prices to be maintained on the ground that there would not be heavy buying anyhow.

William C. Redfield, Secretary of Commerce, whom Judge Gary referred to as "a very wise and thoughtful man," took up the idea suggested to him, that there be gradual price deflation with government supervision and support, and appointed the industrial board. The steel industry was of two minds as to endorsing and accepting price deflation, but its love of a controlled market won the day for the Redfield plan. Any kind of a controlled market seemed better than any kind of an open market. The Industrial Board prices were announced and became effective March 21, involving an average reduction of nearly $7 a net ton in steel products and a general reduction of $4.25 a ton in pig iron. With the reductions previously made the decline from the government war control prices averaged about $11 per net ton in steel products, and $7.25 or more in pig iron, as the disappearance, certain eventually, of some weird removed basing points in pig iron would make the total average reduction slightly greater than the reduction in basis prices.

Then, as is frequently the case in government, club and society affairs, a squabble arose which was both the result and the cause of personal animosities. Insensibly the program which had set out as one of deflation became one of stabilization. The Industrial Board expected the various government activities to buy steel at its stabilized prices. The Shipping Board "accepted" the prices, but stated it had no need to buy any steel. The Navy Department found more than a dozen statutes forbidding it to engage in the operation. The Railroad Administration insisted the prices were too high. The American people love a fight and the Director General of Railroads and the chairman of the Industrial Board went to it. If it had not been for the personal element the Railroad Administration would have stated what was a positive fact, that it had no occasion to buy any considerable tonnage of steel at any price. The steel industry needed orders for several millions of tons of steel of various descriptions. The Railroad Administration needed 200,000 or 300,000 tons of rails, and practically nothing else. To state this fact, however, would have forced the controversy between the Director General and the chairman of the Industrial Board to stop. Finally the Industrial Board resigned, and the attorney general then made public an opinion rendered weeks before that the whole procedure was plainly contrary to law.

By this time, early in May, orders in the steel industry had reached their low point and a revival was forced. The steel corporation adhered rigidly to the March 21 price schedule, while many independents cut prices. A buying movement began and prices soon stiffened. When the steel strike had made steel products scarce a definite advancing tendency became apparent, and the steel corporation, with some support by large independents, then exerted its influence to hold prices down just as in April, May and June prices were held up when many producers were cutting.

Steel and Other Commodities.

This steel market movement might be regarded as complete in itself, the market furnishing its own reasons for what it did. The broader view is that the steel market was influenced by what occurred in other markets. A continued deflation in steel prices had been expected, but it developed that other commodity prices were not deflating. Bradstreet's index number declined slightly until the beginning of March, then hesitated for a couple months, beginning a sharp advance in May. It was already more than 100 per cent above its 10-year pre-war average, while the March 21 steel prices were only 81 per cent above their corresponding pre-war average. The steel trade regarded it as "up to" other commodities to set the example if there was to be any further deflating.

The Strike.

The iron and steel strike, inaugurated September 22, was the culmination of a movement set on foot at the annual convention of the American Federation of Labor, held in St. Paul, in June, 1918. The federation had found the great unorganized iron and steel industry a block to its farther progress. At the Atlantic City convention a year later it was reported that complete organization of the iron and steel industry was greatly impeded because the authorities in many municipalities in Western Pennsylvania refused permits for meetings. Eventually the strike leaders found they had reached a stage where gains and losses to their flimsily constructed "organization" would balance, or the losses predominate. The men enlisted had reached a certain degree of excitement and enthusiasm, and this would tend to die out if time were taken to get more recruits. The strikers and those intimidated by them and those kept out of employment numbered about 40 per cent of the total personnel at the blast furnaces and steel plants. The coke and ore regions were not included. Eventually the strike died out. Its last vestiges, in the Wheeling district, disappeared when the ending of the coal strike enabled mills there to resume.

Partly through the direct action of the strike, but to a very considerable extent by lowered morale of men in employment, the strike involved a total curtailment of between 2,500,000 and 3,000,000 gross tons of finished rolled steel, from the output that would have obtained had the rate of just before the strike been maintained. The loss in pig iron production was of about the same volume.

The New Year's Outlook.

The production outlook for the new year is very promising. The morale and efficiency of the men, since the strike, is not fully restored, but this condiion should be righted in a couple months or so. The question remains as to the extent to which furnaces and mills shall operate on the three-shift instead of the two-shift basis. At some points the change has been made. The three-shift system requires more men, and it is not made entirely clear whether the shorter workday will attract enough men from the outside to meet the increased requirement. It may, however, do even more than that.

In some quarters there is a disposition to parade labor shortage or prospective labor shortage as a reason why selling prices should be higher. The point is not well taken. Much more labor is involved in the fabrication and utilization of the products of the merchant blast furnaces and the steel mills than in their production, and unless the furnaces and mills can take the position that they cannot compete for labor, in wage rates and working conditions, it cannot be held that labor shortage will restrict production of iron and steel more than its consumption.

Pig iron advanced more than $10 a ton from a low point in June to the end of the year. Steel products got to the point of commanding premiums, over the March 21 prices, for early deliveries. The new year will show whether these market conditions are warranted, for they may be in large part the mere outcome of a strike, now fortunately ended. Pig iron capacity is nearly, if not quite, 45,000,000 tons a year, while the 1919 production was only about 30,500,000 tons. If there had been no strike the output would probably have been 33,000,000 tons or a trifle more. The 1919 ingot output was about 33,000,000 tons, against a present capacity of 49,000,000 or 50,000,000 tons. The finished rolled steel output was about 25,000,000 tons, against about 37,000,000 tons capacity. The new year should show full output or find a good excuse for a deficiency. The very bullish views as to prices entertained towards the close of 1919 may find their justification but there is a possibility that they will not. The best hope of the industry lies in large tonnages and low costs per ton.

Electricity in Steel Industry, 1919

Reviews Progress in the Application of Electricity to Steel Mill Drives—Outlines Usual Methods of Operating Electric Drive and Presents Interesting Charts Showing Costs and Other Data.

By G. E. STOLTZ,

Steel Mill Division, Westinghouse Electric and Manufacturing Company.

THE utilization of electricity in the steel mill industry became very general, approximately 10 years ago. Its scope is increasing and although not all the drives are electrified still there has been maintained a natural and ever increasing growth. The preference which electrical apparatus is receiving in this field seems to apply in all other industries. It is interesting with reference to the marine and railway fields that some very noteworthy applications are being made in both of these industries with promise of still greater extension. A number of the large railroads are now electrifying heavy grades and the success which has already been obtained by the installation of electric locomotives for heavy traction work seems to indicate that a general electrification will be made as rapidly as permissable. In the marine field, battle cruisers are building with induction motor propulsion, each cruiser requiring 175,000 hp which is supplied by steam driven turbo generators.

It is impossible to discuss the electrification of rolling mills without first referring to the economies which are now being obtained on steam turbines. This, in addition to the small loss consequent upon the distribution of power over electric transmission lines, accounts in a large measure for the selection of electric motors.

Ten years ago a 3,000 or 5,000 kilowatt steam turbine was considered a large unit for steel mill service. At that time these turbines were usually purchased to supply power to one or two mills, which were selected for electric drives. Today practically all plants have plans prepared for complete electrification of their mills as rapidly as possible, and with this in view turbines of 10,000 to 20,000 kilowatt capacity are installed.

Fig. No. 1 shows the average kilowatt capacity of the turbo generators sold each year for a period of 10 years. The increase in size makes it possible to take advantage of the greater economy of the larger units.

Fig. 2 is a curve showing the increased efficiency obtained as larger units are selected. While the operators were installing larger units from year to year the designing engineers were using higher grade materials in their machines, which permitted them to run the turbines at higher speeds. Both of these conditions tended to reduce the price per kilowatt as is shown in Fig. 3.

In taking advantage of the distribution of power electrically in large plants recent practice is to limit the distribution of direct current power as much as possible. The plant is divided into several units each being provided with a sub-station from which direct current power is supplied for the immediate neighborhood. An alternating voltage of 2,200 or higher is used for general transmission to the larger motors and to the various sub-stations with much greater economy than would be possible if one central direct current 250 volt station were relied upon.

Very recently there is a tendency to tie various neighboring plants together in order to place the spare units at each plant at the disposal of the entire group. This has already been done by several of the plants in the Pittsburgh district, not only for the purpose of reducing the spares but for exchanging power during peak periods in any of the individual plants.

Sixty Cycle Apparatus Predominates.

Several years ago 25 cycle power was better adapted to rolling mill applications than 60 cycles. Today it is possible to meet all the requirements with 60 cycle just as well as with 25 and in many cases apparatus of the higher frequency is preferable. At a meeting held in Pittsburgh recently a paper was presented before the Association of Iron and Steel Electrical Engineers discussing this question, and it was found to be the opinion of practically all the operating men that 60 cycle power is preferable, although many of the engineers present had charge of 25 cycle plants. A great saving would be obtained if a standard frequency could be selected which naturally would be 60 cycles, since 85 per cent of the alternating current apparatus built by the various manufacturers is for 60 cycle power. The cost of 60 cycle apparatus is less than that of 25 cycle equipment. Fig. 5 shows a comparison of the cost of transformers of each frequency.

Plants purchasing small 25 cycle motors usually select either 500 or 750 rpm machines, but where 60 cycle apparatus is installed the speed varies from 700 to 1,200. These motors are usually direct connected to units such as fans where higher speeds can be obtained. Fig. 6 shows the price range of each frequency as well as the saving due to the use of 60 cycles. The area between the two sets of curves of the same frequency represents the price range of the various motors, depending upon the speed selected. Since the lower speed machines are higher in price, at either frequency, the greater area at 60 cycles is an indication of the greater number of available speeds.

Reversing Mills.

Electric drive for reversing mills until recently was usually identified with new, two-high blooming mills. However, within the last year two equipments have been purchased to replace reversing steam engines. The performance of electrical equipments installed several years ago has demonstrated their economy to be much beyond that which can be obtained by steam engines so that at present they are being purchased to replace steam engines now in operation. This phase of electrification can be expected to be carried on in the future as there is a tendency to rehabilitate old plants in order to improve the economies of existing mills. Since greater savings can be obtained by replacing the reversing steam engine than the continuous running engines this naturally is the first application to receive attention.

The number of equipments for reversing bloom mills is not only increasing but the reversing motor is being applied to other types of mills. These equipments are now being installed on plate mills, sheet bar mills, and combination structural and rail mills. There are several equipments in operation now driving universal plate mills, the most noteworthy installation being at the Bethlehem Steel Company, Sparrow's Point plant, where a 17,600 hp reversing motor is installed to drive a 60 inch universal plate mill. Another plate mill installation of note is at the Brier Hill Steel Company where a reversing motor is used to drive the roughing stand of an 84 inch sheared plate mill. The tonnage which can be obtained on a mill of this type has gone far beyond expectations due to the speed of reversal and the possibility of quick manipulation of the metal between passes. Three months after this mill had been placed in operation they were able to roll 103 slabs per hour; three months after this the record was raised to 132 slabs per hour, and now the equipment has been in operation one year without a minute's delay being charged against it.

In this article the author reviews in an interesting manner the technical developments which have been made in the electrification of steel mills. This process has, of course, been going on for a number of years until today practically all plants are making plans for complete electrification. The economies being obtained on steam turbines and the small distribution loss of power over electric transmission lines has expedited the use of electricity.

Two years ago the Inland Steel Company installed a Ward-Leonard-Ilgner set of the non-reversing type to operate their three-high finishing combination rail and structural mill. During the war it was necessary to use this mill for other purposes but within the last year considerable structural material has been rolled. This particular scheme of control permits quick change in speed allowing the mill to slow down for the first few passes in the roughing stand, and then speed up for the finishing passes.

Fig. 4 is a graphic speed curve which shows how the mill is slowed down approximately to 50 rpm for initial passes, and then speeded up for the later passes. Very little trouble is encountered in entering the metal in the rolls as the operator can readily slow the mill down until the rolls grip the metal after which it is immediately brought up to speed again. This method of control which makes it possible to operate at comparatively high speed during the finishing passes makes it possible to roll 20 per cent greater tonnage, and to finish the metal at higher temperatures. This results in a better finished section and also less power consumption.

Average Kilowatt Capacity of Turbines Sold to the Steel Industry During Years 1907-1917 inclusive.

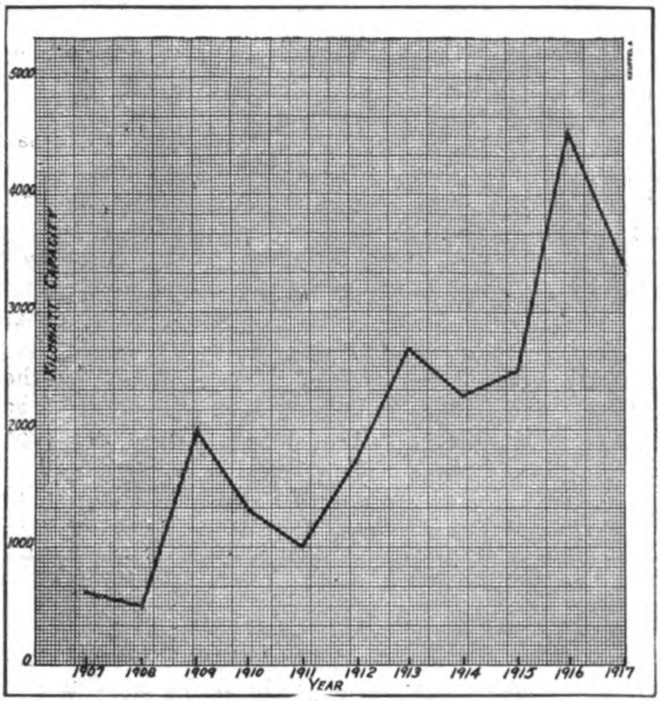


Fig. 1.

Efficiency Chart Showing the Economy of 60 Cycle Turbines Effected by Increased Capacities.

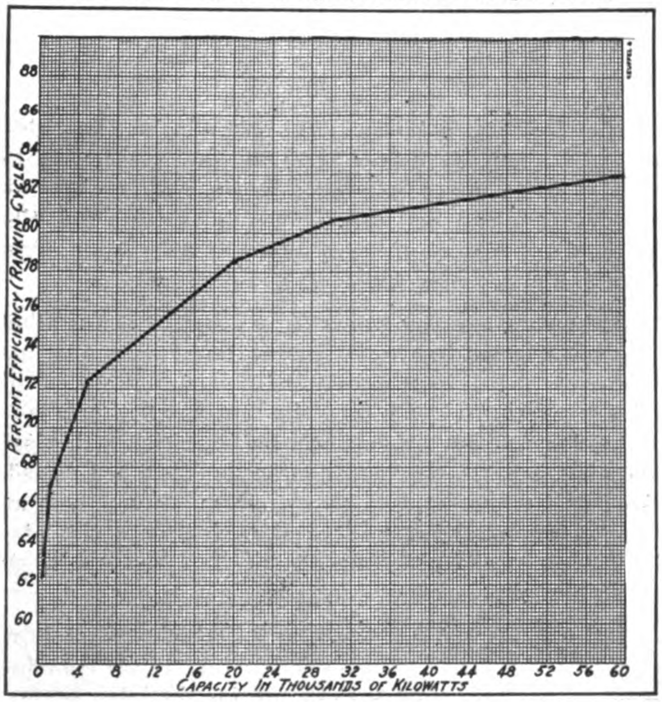


Fig. 2.

When delays are occasioned the mill is brought to rest thus eliminating the power loss due to the friction of the mill.

The Follansbee Brothers are installing a new plant and have selected an electrical reversing equipment for their two-high sheet bar mill. The flexibility of this type of drive makes it very easy to handle the steel over a wide range of passes, and prevents frequent delays and steel rejections due to cobbles.

Continuous Running Motors.

Recent practice continues to favor alternating current motors in preference to large or direct current motors and where speed variation is not necessary the alternating current constant speed induction motor is utilized. Where adjustment is desired the alternating current wound rotor induction motor is used with either a so-called Scherbius system or rotary converter scheme of speed control in preference to an adjustable speed direct current machine. The use of a direct current machine with converting apparatus to change the alternating power to direct current is usually found to be more expensive than one of the alternating current adjustable speed systems. The Central Steel Company is installing an 18 inch bar mill consisting of a 24 inch single stand roughing mill driven by an 850 hp constant speed motor, and an 18 inch train consisting of four stands of three-high rolls driven by a 2,200 hp alternating current adjustable speed motor. The mill may be operated at any speed between 90 and 150 rpm. A system of transfers and repeaters will be used which will automatically return the metal to the rolls reducing the time between passes to a minimum. This

Average Price Per K.W. in Per Cent of 1909 Price, of Turbines Sold Steel Industry During Years 1909-1915 Inclusive.

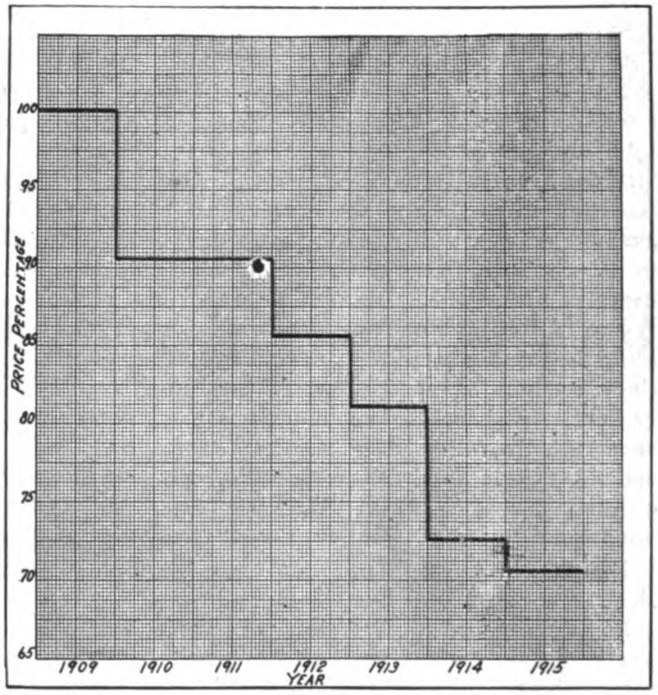


Fig. 3.

in addition to the possibility of adjusting the speed of the motor to the maximum permissable for each schedule will result in a high tonnage mill.

Auxiliary Motor Drive.

In the past a majority of the auxiliaries were driven by direct current motors. At present there is a tendency to apply small alternating current motors wherever possible in order to take advantage of the lower price, and also to eliminate the greater maintenance required by direct current commutating machines. There is no doubt but that the extensive application of direct current motors has been carried much farther than is necessary and in the future we may expect to see operating engineers giving greater consideration to the question of the application of alternating current motors on what may be termed "floor applications."

Another factor which is receiving considerable attention is the use of the flexible couplings. This separates the motor from the gear or driven unit by placing the pinion shaft on its own bearings with a flexible coupling between the pinion and motor shafts. Where a pinion is placed directly on the motor shaft the maintenance on the motor is considerably greater, particularly where the gear drive is allowed to get in bad condition, than where the motor is placed on a substantial foundation and connected to the drive by means of a flexible coupling.

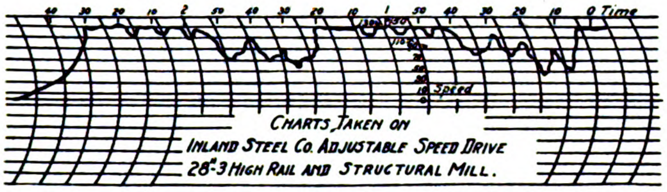


Fig. 4.

Electric Welding.

Editor's Note—Electric arc welding is another use to which electricity has been increasingly placed in the steel industry during the past year or two and which is worthy of some attention in a review of this character. A paper read before the Association of Iron and Steel Electrical Engineers by Alexander Churchward, mentions some points of interest with reference to this subject:

"Electricity as a means of joining of metals, in repairing cracks, or breaks, salvaging defective castings and for metal cutting purposes, all included under the general head of electric welding, although comparatively simple in theory, has been slower in development in this particular field than in any other service in which it has been applied. This slow growth is probably due to two causes—the scarcity of skilled operators and reliable aparatus suitable for performing the actual operation."

"During the last two years, however, arc welding has made great strides, and undoubtedly a great stepping-stone, by means of which it has attained greater prominence and the confidence of the engineering world in general, was through the successful welding of the damaged parts of the interned German ships at New York at the outbreak of the war in the spring of 1917. The work that was done on the engines of the damaged German ships demonstrated to the engineering world in general that electric welding could be depended upon to make permanent repairs, no matter how large or bulky the part to be welded, or the character of the metal."

Comparative Cost of Standard 11000/2300-Volt Transformers Oil Insulated—I Phase—Self-Cooled.

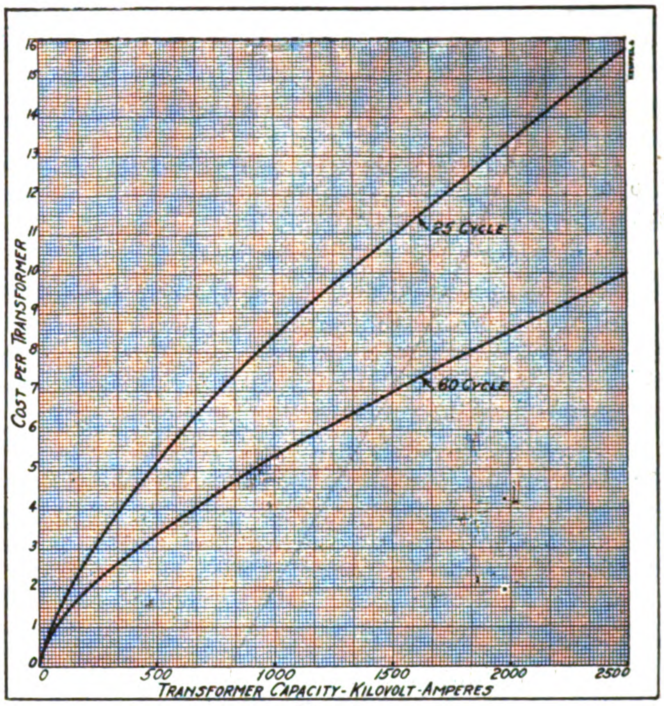


Fig. 5.

Comparative Cost of Low Voltage Squirrel-Cage Motors—5 to 250 Horsepower—Based on Standard Speed Motors Kept in Stock.

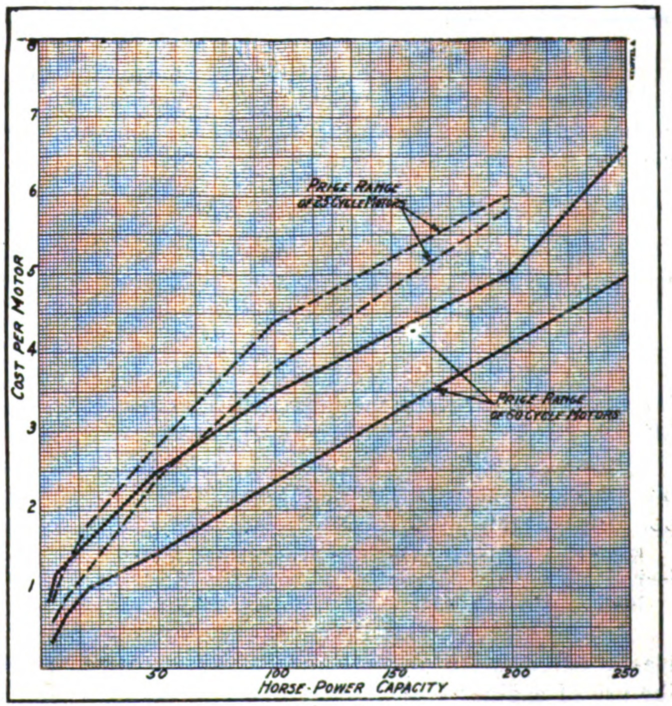


Fig. 6.

Review of Iron and Steel Literature for 1919

A Classified List of the More Important Books, Serials and Trade Publications During the Year; With a Few of Earlier Date, Not Previously Announced.

By E. H. McCLELLAND.
Technology Librarian, Carnegie Library of Pittsburgh.

In spite of certain obstacles and difficulties incident to publication, the works issued during 1919 include several which have greatly enriched the literature of ferrous metallurgy.

Several serials, suspended during the war, have been revived, but some of the important annual and semiannual publications—both domestic and foreign—have been seriously delayed, and importation of foreign works still remains a tedious process.

The printers' strike in New York, which was instrumental in causing the temporary suspension of various journals, affected the book trade also, with the result that several books on ferrous metallurgy, announced for the fall of 1919, have been deferred till the spring of 1920.

It is of interest to note that the technical literature having reference to the iron and steel industry has been somewhat greater in volume and in value than that of recent years in spite of the disturbed conditions of both the steel and publishing industries. The disturbance in the latter industry however diminished the literature scheduled for the year.

The following brief list includes the most important publications of the past year together with a few of earlier date not previously noted in these columns, and perhaps not very widely known.

Iron and Steel Metallurgy.

American Society for Testing Materials—Standard specifications for gray iron castings. English-Spanish edition. 1919. Superintendent of documents, Washington, D. C.

Astruc, Marcel—La Metallurgie, a la portée de tous; fonte fer, acier, aciers speciaux. 192 pp. 1919. Albin Michel, Paris.

Australia—Advisory Council of Science and Industry. Manufacture of ferro-alloys and alloy steels. 46 pp. 1918. Melbourne.

Report of a special committee appointed to investigate manufacture from the raw materials occurring in Australia.

Bibliography, pp. 45-46.

Bower, Clifford, O.—Practical shell forging and the plastic deformation of steel and its heat treatment; for the use of engineers, shell shop managers, forge-masters, inspectors, foremen, students and all engaged upon projectile manufacture, and especially those interested in the after war reorganization and conversion of power forging plants for purposes of commercial utility. 279 pp. 1919. Longmans, Green & Co., New York.

A valuable work, not only giving details of British manufacturing processes, but presenting principles which will be of permanent value.

Cain, J. R. & Pettijohn, Earl—A critical study of the Ledebur method for determining oxygen in iron and steel. 33 pp. 1919. Government Printing Office, Washington, D. C. (Technologic papers of the Bureau of Standards. No. 118).

Camp, J. M. & Francis, C. B.—Making, shaping and treating of steel. 604 pp. 1919. Carnegie Steel Company, Pittsburgh.

Based on a course in ferrous metallurgy for salesmen and other non-technical employes of the Carnegie Steel Company. Assumes no previous knowledge of physics or chemistry and includes enough of these sciences to afford a basis for the course.

A concise, but comprehensive treatment of the various processes in manufacture of iron and steel. Includes fuels, refractories, coke manufacture, electric furnace practice, forging and heat treatment, and is particularly valuable for the section on rolling mill practice, which constitutes the best treatment of this subject available at the present time.

Carnegie, David, & Gladwyn, S. C.—Liquid steel; its manufacture and cost. Ed. 2. 526 pp.? 1918. Longmans, Green & Co., New York.

Differs only slightly from the first edition (1913). Contains an additional chapter on development of electric steel manufacture in Canada. Deals chiefly with costs and, even for comparison, the figures have now lost much of their value.

Ellis, W. W.—The metal mixer; the easiest, simplest and most exact method of mixing iron by chemical analysis, with tables and ready made mixtures. 56 pp. 1919. The author, 5912 Dover street, Oakland, Cal.

Pamphlet for the foundryman. Carelessly written.

Ferasson, Louis—L'Industrie du fer. 219 pp. 1918. Payot et Cie, Paris.

Deals with manufacturing processes, statistics and trade.

Giolitti, Federico—Il trattamento termico preliminare degli acciai dolci e semi-duri per costruzione meccaniche. 621 pp. 1918. U. Hoepli, Milan.

A valuable work. In recognition of the importance of his work in ferrous metallurgy the author has been presented with the Bessemer medal of the Iron and Steel Institute.

Hatfield, William Herbert—Cast iron in the light of recent research. Ed. 2, revised and enlarged. 292 pp. 1918. Charles Griffin & Co., London.

First edition appeared in 1912. In the present edition special consideration has been given to malleable cast iron, with attention to research during the war.

Hunt, Robert W.—A history of the Bessemer manufacture in America [and] The evolution of American rolling mills. 54 pp. n.d. Robert W. Hunt & Co., Chicago.

"Foreword" is dated December 9, 1918.

Reprint of two addresses before the American Institute of Mining Engineers in 1876, and the American Society of Mechanical Engineers in 1891, respectively.

Jacques, Louis—Ideés générales sur les installations d'aciéries et de gros laminoirs. 3 vols. 1919?

Vol. 1. 96 pp.
Vol. 2. 164 pp.
Vol. 3. 335 pp.

Moldenke, Richard—Coremaking. 45 pp. 1918. Corn Products Refining Company, New York.

Brief treatment, dealing mainly with materials, requirements and tests of foundry cores.

Oberg, Erik Valdemar, & Jones, F. D.—Iron and steel; a treatise on the smelting, refining and mechanical processes of the iron and steel industry, including the chemical and physical characteristics of wrought iron, carbon, high-speed and alloy steels, cast iron and steel castings, and the application of these materials in machine and tool construction. 328 pp. 1918. Industrial Press, New York.

The authors are editors of *Machinery* and both have previously written authoritatively on machine shop work. The present work is a text-book, general in scope, designed primarily to afford a knowledge of "the various commercial forms and grades of iron and steel products, and the particular class of service for which the different grades are applicable." Cold drawing and cold rolling are treated more fully than in other general text-books, up to the present time.

Osann, Bernhard—Lehrbuch der Eisen- und Stahlgiesserei. 572 pp. New edition, 1918. Hermann Meusser, Berlin.

Osann, Bernhard—Lehrbuch der Eisenhuettenkunde. 664 pp. 1918. Hermann Meusser, Berlin

Osborn, Chase S.—The iron hunter. 316 pp. 1919. Macmillan & Co., New York.

Primarily an autobiography. Author claims to have visited virtually every important iron-ore deposit in the world. Contains some descriptions of mining and metallurgical processes.

Scott, Howard—Effect of rate of temperature change on the transformations in an alloy steel. 91-100 pp. 1919. Government Printing Office, Washington, D. C. (Scientific papers of the Bureau of Standards. No. 335.)

Tiemann, Hugh P.—Iron and steel; a pocket encyclopedia. Ed. 2. 514 pp. 1919. McGraw-Hill Book Company, Inc., New York.

First edition appeared in 1910. A brief but comprehensive treatise of high merit. Deals concisely with iron and steel, defining terms and processes—both modern and obsolete. Technical, but useful also to the non-technical reader. One of the most valuable books available.

Statistics and Trade.

American Iron and Steel Institute—Annual statistical report for 1918. 96 pp. 1919. The Institute, New York.

Much of the material was previously published in the Bulletin of the Institute.

American Iron and Steel Institute—Maximum prices on iron and steel products, with differentials and extras. 176 pp. November 15, 1918. The Institute, New York.

As agreed upon by government officials and committees of the American Iron and Steel Association.

Pages 152-176 are blank "to be used for additional price announcements."

Burchard, Ernest F.—Iron ore, pig iron and steel in 1917. Published April 28, 1919. Government Printing Office, Washington, D. C.

Advance publication comprising pages 557-603 of the United States Geological Survey's "Mineral Resources."

Clark, Martha B. comp.—Preliminary report on the mineral resources of the United States in 1918. 106 pp. Published August 7, 1919. Government Printing Office, Washington, D. C.

Wholly statistical. Includes iron and steel.

Constitutes the initial result of a laudable attempt "to furnish statistics of mineral production in the United States within six months, if possible, after the end of the year covered by the statistics."

Hatch, F. H.—Iron and steel industry of the United Kingdom under war conditions. 167 pp. 1919. Harrison & Sons, London.

Kovaleff, P.—The iron industry in Russia. 16 pp. 1919. Russian Economic League, Woolworth Building, New York.

Paper at meeting of the Association of Russian Engineers for Relief of Russia. New York, January 19, 1919.

Metal statistics—427 pp. Ed. 12. 1919. American Metal Market Company, New York.

This valuable annual, first appearing in 1908, was originally confined to non-ferrous metals, but has become one of the promptest and most reliable sources of information for statistics of the iron and steel industry. The present volume, though containing the same number of pages as the previous issue, is more compactly arranged and contains additional data.

Mineral industry during 1918. 937 pp. 1919. McGraw-Hill Book Company, Inc., New York.

Pages 351-410 are devoted to a review of iron and steel during 1918, by E. F. Cone. This review includes both statistics and technology, giving interesting information regarding the industry abroad, especially in Belgium. Footnote references but no bibliography.

National Federation of Iron and Steel Manufacturers—Statistical report. 1918. Compiled by G. C. Loyd. 68 pp. 1919.

This Federation, in 1918 took over the work of the Iron, Steel and Allied Trades Federation, which in 1915 took up the statistical work of the British Iron Trade Association. The present report, issued July, 1919, includes British and foreign statistics of both iron and coal.

Standard iron-steel-metal directory, 1918—A complete index of iron and steel manufacturers, iron and brass foundries, metal manufacturers, etc., with a report showing corporation or co-partnership, capital, officers, purchasing agents, sales managers, headquarters and branch plants, equipment, capacity, products, fuel and raw materials used, 1918. 1160 pp. 1918. Atlas Publishing Company, Inc., New York.

Refractories.

Ross, Donald W.—Silica refractories; factors affecting their quality and methods of testing the raw materials and finished ware. 84 pp. 1919. Government Printing Office, Washington, D. C. (Technologic papers of the Bureau of Standards. No. 116.)

"The harder portions of the Medina formation in Blair and Huntingdon counties, Pa., have proved to be particularly suited for steel furnace work."

Insley, Herbert, & Klein, A. A.—Constitution and microstructure of silica brick and changes involved through repeated burnings at high temperatures. 31 pp. 1919. Government Printing Office, Washington, D. C. (Technologic papers of the Bureau of Standards. No 124.)

England—Geological Survey—Refractory materials; ganister and silica-rock, sand for open-hearth steel furnaces, dolomite. 233 pp. 1918. London. (Special reports on the mineral resources of Great Britain, Vol. 6.)

Issued in the series "Memoirs of the Geological Survey."

Much important work on refractories is now going on, and the results of this work can be followed only in current periodicals. For example, a "Symposium on refractories" (*Journal of Industrial and Engineering Chemistry,* December, 1919, pp. 1145-1157) conducted by the American Chemical Society offers several good papers. Men in the steel industry will find much of value in the *Journal of the Society of Glass Technology* which has a section devoted to abstracts of current literature on "fuels, refractories and furnaces."

Trade Literature.

In following the technology of iron and steel, trade literature does not usually receive the consideration which its importance merits. Catalogues and other trade publications usually represent the highest standards in illustration, printing, and general make-up, and are in many cases more costly to produce than books on the same subjects. Moreover, these trade publications often contain the most up-to-date information available, technical data appearing here long before being incorporated in books or even in trade journals. Prior to the publication of the book by Camp & Francis (mentioned above) the best information on American rolling-mill practice was to be found in trade literature.

Space will not permit the enumeration of any large number of these trade publications but the three listed below—all issued by Pittsburgh manufacturers—are noteworthy examples.

Mesta Machine Company—Plant and product of the Mesta Machine Company. 127 pp. 1919.

A well-illustrated description, giving valuable technical information regarding prime movers and steel mill equipment manufactured by this company.

Tate-Jones & Company, Inc.—Normalizing and annealing; preliminary chapter from the Heat Treating Hand Book. 48 pp. [1919].

Advance printing of chapter 5 of a forthcoming handbook. Presents valuable technical information.

United Engineering & Foundry Company—Bulletins.

A set of valuable publications containing much technical information. Several bulletins appeared during 1919. Among the subjects included are: Plate mills, merchant mills, precision cold strip mills, annealing boxes, hot and cold saws, straightening presses and forging presses.

Serials.

Several of the important serial publications which are mainly statistical have been mentioned above.

The *Proceedings of the Association of Iron and Steel Electrical Engineers* (Pittsburgh) for 1918, forms a volume of 735 pages. It appeared in November, 1919, giving in final form the papers before the Society on various applications of electricity to steel-mill work.

Volume 3 of the annual *Reports of the Progress of Applied Chemistry,* published by the Society of Chemical Industry (London) includes a review of the progress in metallurgy of iron and steel for the year 1918. This review embodies numerous references to the original literature of the subject.

Volume 98 of the *Journal of the Iron and Steel Institute* contains 539 pages. It covers the last half of the year 1918, summarizing with its usual thoroughness the current literature in all languages. Volume 99, covering the first half of the year 1919, has resumed the bibliography of books on metallurgy and allied subjects, omitted from several preceding volumes.

The *Proceedings* of the American Drop Forge Association, 1919, forms a volume of 125 pages.

A publication not widely known in America is the *Science Reports of the Tohoku Imperial University,* (Sendai, Japan), printed in English and German. Several numbers of volume 8, 1919, have been received. These reports devote considerable attention to iron and steel, but, as a rule, the papers are reprinted from other sources.

Metallographists will be interested in the "Internationale Bibliographie" which appears, in form for "card indexing," in the issues of the *Zeitschrift fur Metallkunde.*

The Blast Furnace and Steel Plant in June, 1919, began a special "power plant section" devoted to the features of practical power plant engineering in steel mills.

Other Technical Books.

Progressive steel men are likely to be interested in the literature of many subjects allied to ferrous metallurgy. The list of recent books which might be suggested is too long for inclusion here, but various sources of information are easily available.

In most libraries and bookstores may be found the *Publisher's Weekly,* (R. R. Bowker & Company, New York), giving prompt notice of new books published in this country; also the *Cumulative Book Index,* (H. W. Wilson Company, New York), which appears monthly (except July and August) and cumulates annually. Both of these publications include books on all topics, but the latter provides an arrangement by subjects.

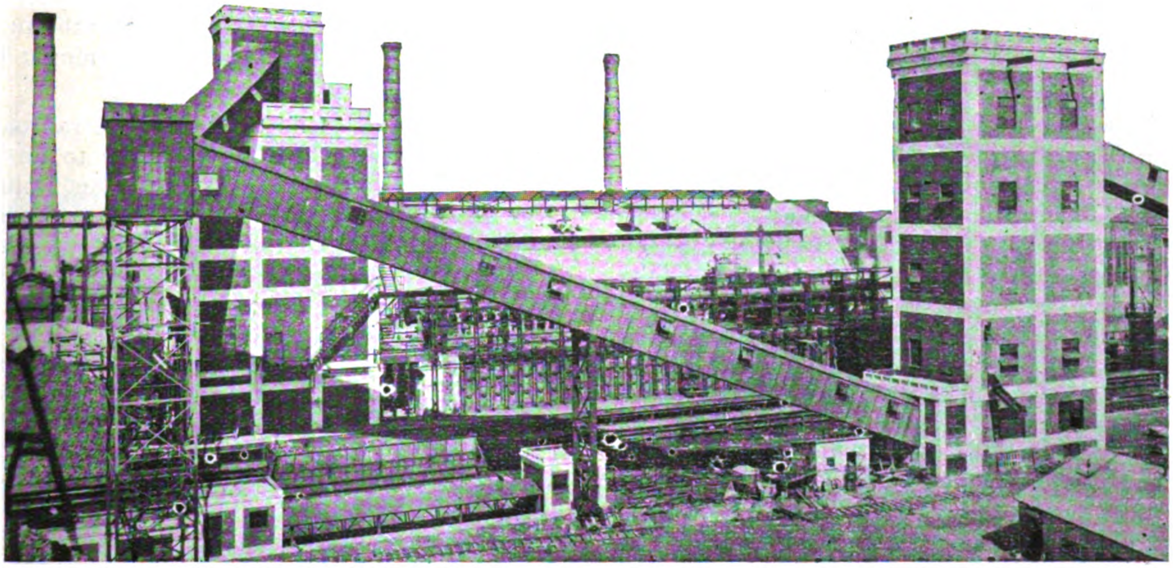
The annual *Chemical Engineering Catalog* (Chemical Catalog Company, Inc., New York) contains a list of books, mainly on pure and applied chemistry, giving information regarding contents of the books, and in the latest edition, giving dates of publication—a very important feature. The *Annual Chemical Directory of the United States* (Williams & Wilkins Co., Baltimore) also contains a list of chemical books of the year and a list of scientific journals, both domestic and foreign.

The Carnegie Library, of Pittsburgh, publishes quarterly a *Technical Book Review Index* recording and abstracting the book reviews in a large number of current scientific, technical, and trade journals published in the United States and abroad.

By-Product Coke Oven Department

ALTHOUGH accurate figures regarding the production of by-product coke for the year are not available, it is safe to say that by-product coke constituted 60 per cent of the total coke production for the year; 1919 being the first year in which total by-product coke production exceeded beehive production.

This department reviews the technical advances made in by-product coke oven practice and describes one of the most modern installations. The article in this section comparing foreign and American by-product coke ovens is of particular interest.



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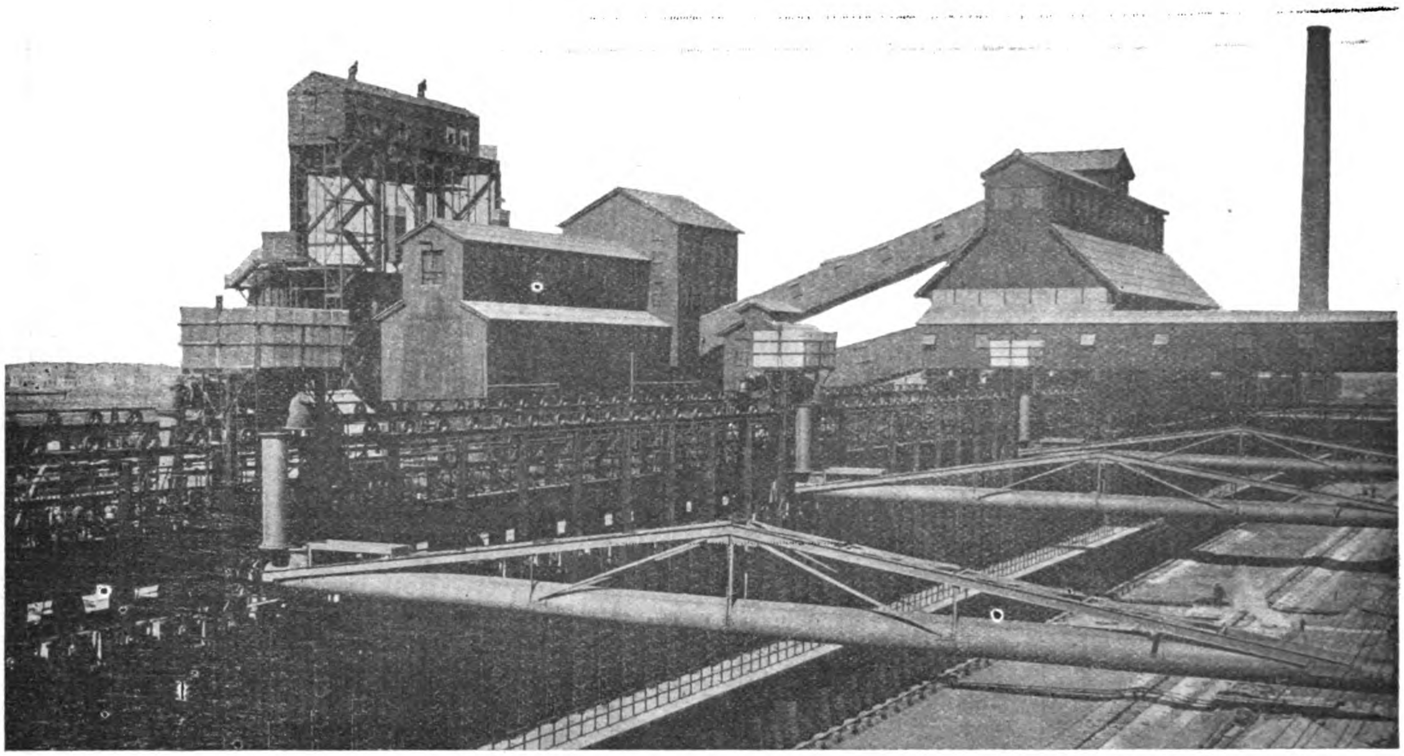


View along front of ovens looking north, showing overhead gas mains, coke belt gallery, coal bin and coal preparation plant.

New By-Product Plant at Indiana Harbor

Semet-Solvay Company Starts One Hundred and Twenty-Oven By-Product Coke Plant at Indiana Harbor Plant of The Steel & Tube Co. of America, to Supply Coke for Blast Furnaces.

THE by-product plant of The Steel and Tube Compan of America, situated at Indiana Harbor, was finished in the early summer of 1919 but was not put into operation until September 1 of the same year on account of commercial conditions. The plant is designed to furnish coke for the blast furnaces of The Steel and Tube Company of America, and gas and tar for the steel plant immediately contiguous to the coke oven plant. The other by-products, that is, concentrated ammonia liquor and light oil, are sold in the open market. The plant as situated has direct connection with the Indiana Harbor Belt Railway through which it has connections with all the railroads in the district. The present plant of 120 ovens consists of two blocks of 60 ovens each, sufficient space being reserved to construct an additional 120 ovens of the same type. The ovens are 36 feet long, 19 inches wide at the pusher end, 20 inches wide at the discharge end, and have a capacity of slightly more than 15 tons of coal per charge. They are of the Semet-Solvay standard 6-36-19½ individual regenerator type. They are lined throughout with silica brick and are covered with about three feet of brick work, making them amply strong for carrying the charging car and its load. Reversals are effected by an automatic reversing damper mechanism at the end of each block, and the waste gases pass two 200-foot Kellog stacks at the end of each block. Air for the regenerator is supplied by two fans.

Upon a conservative estimate, it is expected that the present plant will have a capacity for coking at least 74,000 net tons of coal per month, and that the screened furnace coke product will amount to at least 45,000 tons per month.

Coal is received directly from the railroads, and is handled by two 70-ton locomotives to an unloading station. The yard track system is equipped with a 50-foot 200-ton scale. The coal is set for delivery on a track leading to the McMyler Interstate car dumper by the steam locomotives. The cars are then placed on the platform of the car dumper and removed from it by an electric car pusher which travels on a narrow gauge track parallel to the track on which the coal cars are placed. The car pusher is a 20-ton electric locomotive. The car dumper has a capacity of one car every 2½ minutes, with a vertical lift of 65 feet and a maximum lift of 280,000 pounds; the machine being operated by electricity, automatically controlled. The coal is received from the car dumper on a 70-ton transfer car which delivers it into a coal bucket which extends the full length of the coal stocking area. The coal stocking area has a capacity of 300,000 tons of coal, and is served by a 280-foot span Heyl & Patterson traveling bridge with a bucket of 10-ton capacity.

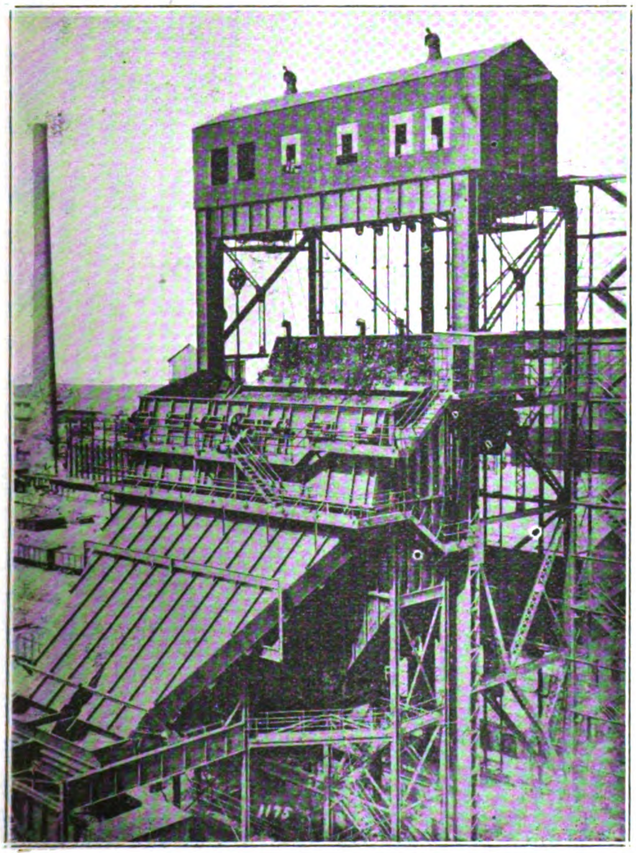
This bridge can store and reclaim coal at the rate of 600 tons per hour. The coal can be put directly from the car dumper through the finishing system, or can be reclaimed from the stock pile and put through the finishing system, by-passing the car dumper. The coal is transferred from the receiving hoppers by a steel apron conveyor of 300 tons per hour capacity to a Heyl & Patterson Cornish roll crusher. From this crusher the coal is elevated to the mixing bins, which are four in number, with a capacity of 250 tons each. Four different kinds of coal can be mixed and transferred from the mixing bins to two No. 8 jumbo hammer mills. These mills deliver into a horizontal screw conveyor, which transfers the coal to a vertical belt elevator with steel buckets to the top of the structure, and delivers on to an inclined belt conveyor, which in turn delivers the coal into a bin placed over the top of the ovens. A shuttle conveyor is placed in this bin so that the various kinds of coal can be delivered to the three different compartments of the bin. These compartments have a total capacity of 3,200 tons. From these compartments the coal is drawn directly into a four-hopper charging car for delivery into the individual ovens.

For the time being, it is contemplated to bring coal into the plant by rail alone, although there is reserved on the canal, which bounds the property to the south, sufficient space for the construction of a dock with vessel unloading and coal handling equipment.

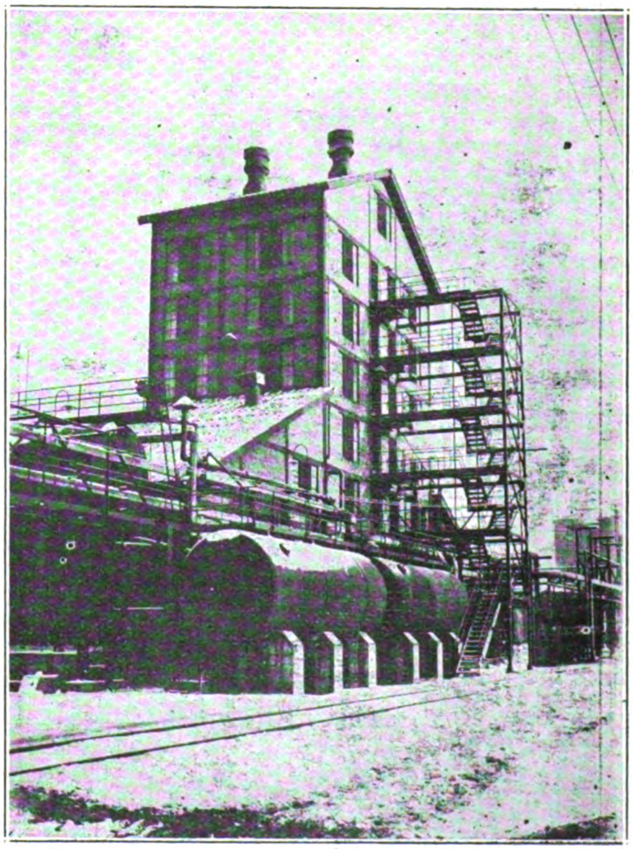
The coal thawing shed is constructed of concrete and tile. This is of a capacity to house 10 cars, and will be used when necessary in connection with the car dumper. It is fitted with the necessary furnaces, fans, etc., for moving and thawing the coal. All of the apparatus handling the coal through the plant is electrically driven.

Each oven block is served with a Wellman-Seaver-Morgan pusher for removing the coke from the ovens. The coke is pushed through a modern coke guide, into quenching cars of a most modern type, the gates of which are actuated by compressed air from the cab of the engineer. The quenching cars are hauled by a 20-ton electric locomotive.

The plant is equipped with three quenching cars place at a quenching station situated about 100 feet from the end of the oven block. A car of coke is quenched in 55 seconds. The steam caused by the quenching is conducted in this station to an elevation of about 75 feet. The coke is then transferred to a modern equipped coke wharf, 135 feet long, of sufficient capacity to store about 75 tons of coke. The bottom of the coke wharf is on an angle of about 35 degrees, and the coke flows by gravity into a rotary feeder which delivers it on to a belt conveyor. Thence it is transferred to the coke screening and loading station, which is equipped with a disc scalping screen, which receives the whole product. The coke passing over this screen is delivered into a roll crusher. Both the coke passing through the roll crusher and scalping screen is delivered into a bin of about 150 tons capacity. The bottom of this bin is equipped with



Car dumper in operation.



Light oil and benzol plant.

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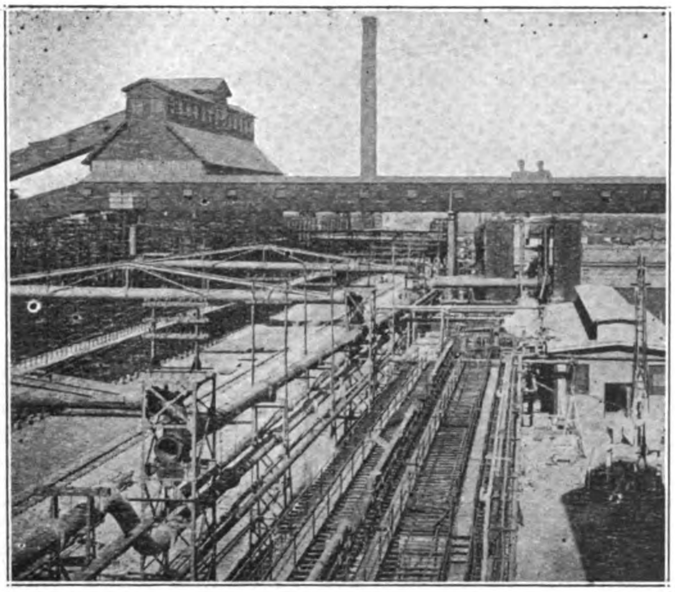


View along top of cooling coils. The two primary coolers are shown slightly toward the right under the coke conveyor gallery with pump house to the right.

two sizing disc screens. Each of these screens delivers to a boom loading belt which can be lowered into a rack or gondola car. These cars are set in place to receive the coke by an electric driven car haul. The mechanism for controlling the car haul, the raising and lowering of the boom belt, and the starting and stopping of this belt is located in one cab, and is taken care of by one man. The above described machinery has a loading capacity of 95 tons per hour. The by-product which passes through the sizing screens is conveyed by belt conveyors to a separate building, having three bins with a capacity of 120 tons each. These bins are equipped with two rotary perforated plate screens. The product entering these bins passes through the two rotary perforated screens for the separation of No. 1 nut, No. 2 nut, and breeze. These bins are equipped for loading the product into open top or box cars. The box car loader is of a Ticknor-Manierre type, and has a capacity of 45 tons per hour. The track upon which the box cars are set for loading is graded so that they will leave the loader by gravity.

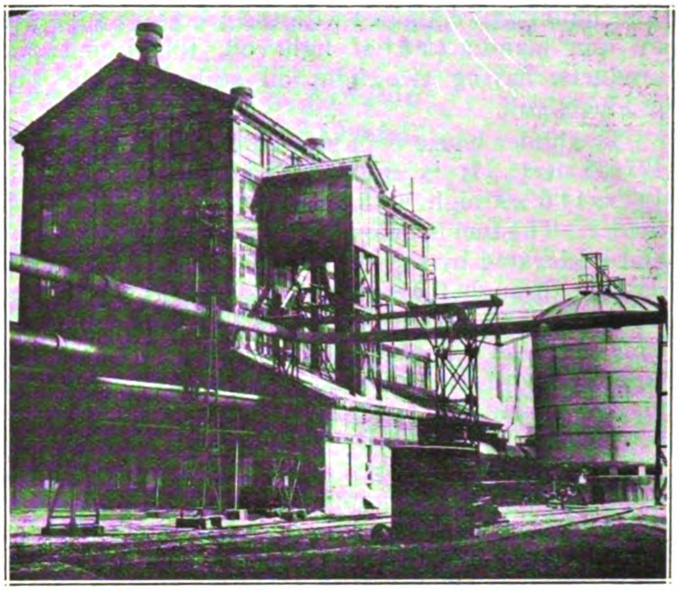
Gas pressure on the hydraulic main is controlled by a Royce electric regulator. The gas is drawn from the hydraulic mains through primary cooling apparatus, then into the by-product building through three Connersville blower exhausters which are direct driven by twin steam engines of 250 hp each. The gas then passes through tar extractors, five-compartment ammonia washers which are housed inside the building, and then into oil washers placed outside. After washing, the surplus gas is conveyed through a 36 inch diameter cast iron underground pipe through a Venturi meter, and thence to the steel plant, situated about 400 feet from the coke oven plant. All of the

Pushing an oven of coke.

washing apparatus is of the grid type.

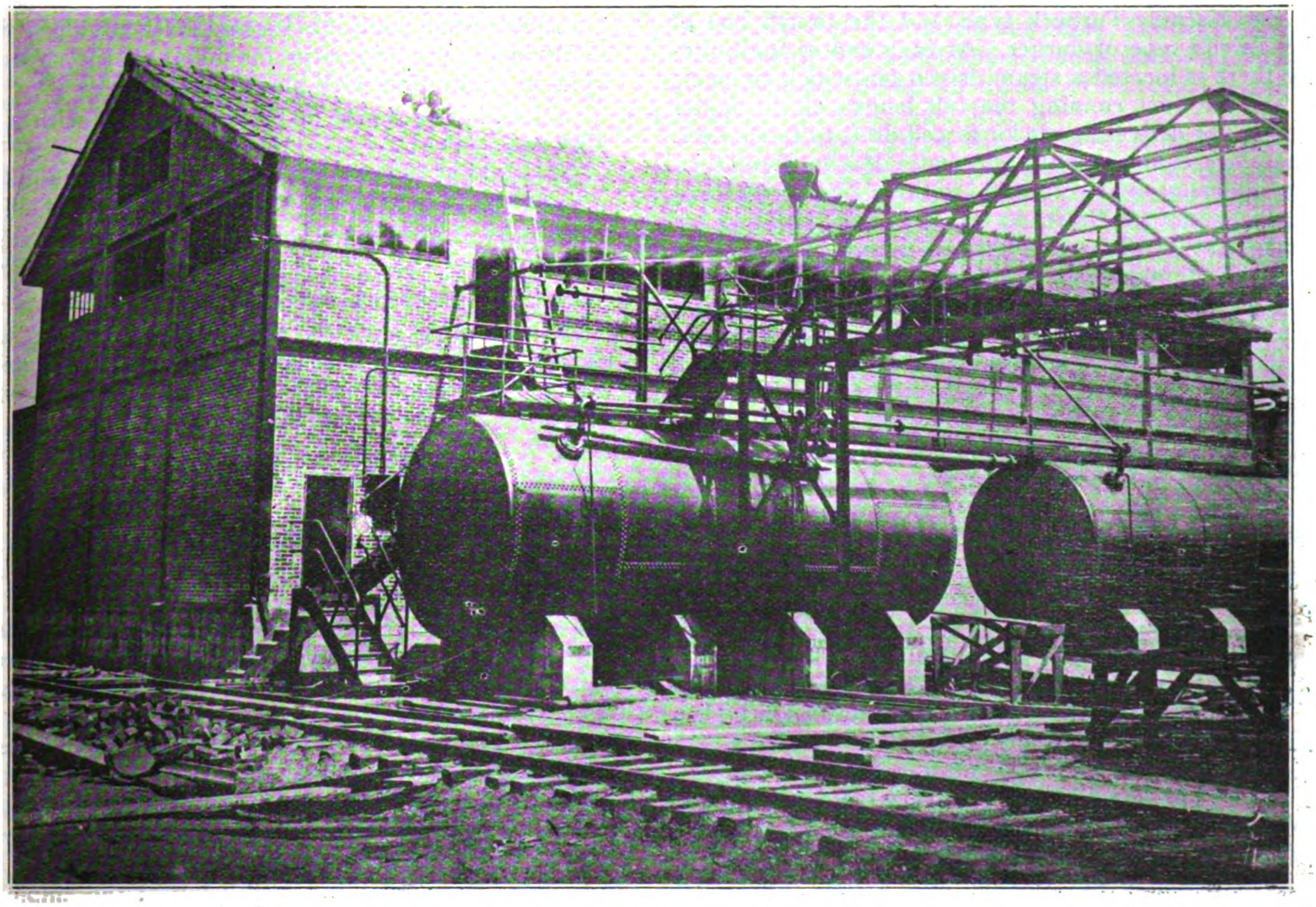
The pump house is constructed of steel and brick, and contains all the pumps necessary for the circulation of ammonia liquors, tar and cooling waters. The ammonia liquor secured from the washing of the gas is conducted through pipe lines into three weak-liquor tanks. The tar is decanted in regulation Semet-Solvay decanters and delivered through pipe lines into three tar storage tanks, two having a capacity of 497,000 gallons each, and one having a capacity of 1,040,000 gallons. The tar storage tanks are equipped with a brick pump house containing the necessary pumps for loading the product; and also, with a dehydrator for drying the tar when necessary.

The ammonia concentration building is constructed of brick and steel, six stories high, and is 90x70 feet, containing the necessary apparatus for the concentration of all the ammonia liquor made, having three complete ammonia stills with the necessary milk of lime apparatus, with sufficient space for one additional still. Adjacent to this building are the necessary weak-liquor storage tanks; also the three concentrated ammonia storage tanks with a capacity of 485 cubic meters each. These tanks are equipped with a pump house containing the pump for the loading of the stored product. This building is equipped with all the necessary pumps, etc., for taking care of the ammonia liquor. The building is equipped with a traveling crane for the dismantling and repairing of the various apparatus. Incidental to this building are 96 stacks of cooling coils for cooling the liquor used in washing the gas.



View of ammonia plant looking southeast, showing main steam line from boiler house and exhaust steam line entering ammonia concentration plant.

The light oil building is constructed of steel and brick, is 111 feet long, 24 feet wide, and about six stories high. It is equipped with a traveling crane



House over benzol storage tanks.

for dismantling and repairing the various apparatus. This building is equipped with the necessary apparatus for the manufacture of light oil, toluol and pure products, having two light oil stills and one pure products still.

The boiler house is of steel and brick construction, 175x55 feet. It is equipped with a steel fuel bin, 133'xx14'6"x9' high, with a capacity of 325 tons of coke breeze. The fuel is unloaded through the track hopper and is elevated by the electrically driven Peck carrier, passing through the electrically driven rough crusher onto a 24-inch electrically driven belt conveyor which runs over the top of the fuel bin. This conveyor is equipped with a tripper, so that the fuel can be unloaded at any point desired. The boiler equipment consists of six Stirling-Babcock boilers of 600 hp each at 140 pounds steam pressure with 120 degrees superheat. Each unit is equipped with a B. & W. superheater and also a Type B Coxe stoker for burning crushed coal or coke breeze. These stokers are covered with a water cooled arch installed by the Combustion Engineering Corporation. There is an ash tunnel installed under the boiler setting which is fitted with a narrow gauge track and steel car for the removal of ashes to one end of the building. These ashes are delivered onto the Peck carrier through a steel hopper equipped with a plunger feeder. This conveyor delivers the ashes into an overhead steel bin of 100 tons capacity, from which they can be loaded into a gondola railroad car by gravity. Four of the boiler units are equipped with gas burner appliances, three of them of the Bircholz-Turbeck type, and the fourth one of the Toledo type of burner. At each end of the building there is located a steam driven fan which connects to the air duct running the full length of the boiler setting, for delivering air for forced draft to the boilers. These are equipped with automatic Mason regulators. The boilers are also connected to three 175 foot Kellogg stacks for natural draft. At the end of the building are located the necessary boiler feed pumps consisting of three Worthington steam-driven pumps. Also, in this building is located a steam-driven fire underwriters pump having a capacity of 1,500 gpm. This building is also equipped with a Cochrane open boiler feed water heater of 7,400 hp. The waste water from the Coxe stoker arches is piped to this heater and is of sufficient quantity to run the boilers. Each boiler unit is equipped with a steam flow meter. Boiler feed water is measured by a Venturi meter. The building is designed so that future extensions may be added.

The mill water supply is furnished by the steel plant and is delivered to the coke oven plant through a 30 inch diameter pipe line into a 90x18-foot standpipe. The plant is thoroughly equipped with fire fighting apparatus, consisting of a fire underwriters pump of 1,500 gpm capacity which delivers into 8 inch underground mains, terminating in 13 hose hydrants which are equipped with the necessary hose-houses and appliances. This installation is capable of carrying 125 pounds pressure. There is an electricall ydriven auxiliary supply pump located on the oven property, to be used as an emergency, having a capacity of 5.500 gpm. The drinking water system consists of one deep well about 600 feet deep, having a capacity of 12 gallons per minute. The water from this well is piped throughout the plant, the pipe lines terminating in bubbling fountains, of which there are 15. The pneumatic tank system is used for the distribution of the water.

The electric power is furnished by the steel plant through an underground conduit system terminating in the coke plant power house and sub-station. The power house is equipped with the necessary apparatus for transforming the 2,300 volt ac current to 440 volt ac current for use in the induction motors, as well as the lighting system throughout the plant. The power house is also equipped with motor-generator sets for converting ac current into dc current, for driving pushers, charging car, coke guides and quenching cars. The sub-station is constructed of steel and brick and contains two rotary converters, changing the 2,300 volt ac current to 230 volt dc current. This equipment is used for driving the transfer car and bridges, car dumper and car pusher. The coke oven plant is connected with the steel plant by a tunnel running under 10 railroad tracks. This tunnel is 450 feet long, made of concrete, and accommodates the gas and water pipe lines and the lead-covered electric cables, with sufficient room for a walkway.

The auxiliary buildings consist of the following:

A steel and brick machine shop and store room, 130x66 feet, heated by a hot air system, equipped with modern machinery for taking care of all of the repairs for the coke oven plant:

A laboratory built of brick and steel, equipped with all the necessary apparatus for doing all the chemical work in connection with plant operation:

A locomotive house of brick and steel, with a pit 30x4 feet.

A brick office building having a basement and two stories, housing also the first aid room, which is thoroughly equipped for attending to accident cases, and providing space for time clocks and time cards.

A fully equipped blacksmith shop.

A washhouse with six rooms fully equipped with shower baths, wash bowls, etc., for the accommodation of employes; together with small auxiliary wash and locker rooms located at various points about the plant in connection with the main buildings to serve foremen and other employes whose duties are in the detached buildings.

An oil house equipped with pumping apparatus for handling the several kinds of oil.

All of the buildings, conveyor galleries, etc., with a few exceptions, are covered with Federal tiled roofs. The plant is equipped with an open concrete sewer system covered with concrete slabs. In addition, there is a steam-heated, electric-lighted garage with concrete floors, which will accommodate 15 automobiles.

It will be observed, then, that the plant is not only designed for the production of high grade coke with maximum efficiency of plant operation, but that great care of has been taken to provide all necessary equipment for the comfort and well-being of the employes working on the plant.

The By-Product Coke Oven Industry, 1919

Although Not as Active as During the War Several Notable Installations are Placed in Operation—List of New Ovens. Koppers Company Wins Patent Suit Over Wilputte.

By C. J. RAMSBURG.
Vice President, The Koppers Company.

WHILE the year 1919 has not been one in which the by-product coke oven construction and development has been in the atmosphere of glamor that surrounded it during the war, nevertheless the progress made with regard to capacity placed in operation has been very large.

The following ovens have been placed in operation by the Koppers Company:

Owner or Operator.	No. of ovens
Dominion Iron & Steel Co., Sydney, Nova Scotia	120
Providence Gas Company, Providence, R. I.	40
Jones & Laughlin Steel Co., Pittsburgh, Pa.	240
Rainey-Wood Coke Company, Swedeland, Pa.	110
Carnegie Steel Company, Clairton, Pa.	128
Tennessee Coal, Iron & Railroad Co., Birmingham, Ala	72
Total	710

The following ovens have been placed in operation by the Semet-Solvay company:

Ford Motor Company, Detroit, Mich.	120
Mark Manufacturing Company, Indiana Harbor, Ind.	120
Lackawanna Steel Company, Buffalo, N. Y.	60
Total	300

The following Wilputte ovens have been placed in operation:

Wisconsin Steel Company, South Chicago, Ill.	88
Citizens Gas Company, Indianapolis	40
Total	128

The following Koppers ovens are under construction at the present time and will go into operation during the first half of 1920:

Owner or Operator.	No. of ovens
Jones & Laughlin Steel Co., Pittsburgh, Pa.	60
Bethlehem Steel Co., Sparrows Point, Md.	180
Donner Union Coke Corporation, Buffalo, N. Y.	150
Birmingham Coke & By-Products Co., Birmingham, Ala.	50
Domestic Coke Corporation, Fairmont, W. Va.	60
Pittsburgh Crucible Steel Co., Midland, Pa.	100
Total	600

The following Semet-Solvay ovens are under construction:

Sloss-Sheffield Steel & Iron Co., Birmingham. Ala.	120

This makes a total of 1,138 ovens placed in operation during 1919, and 720 under construction.

The year has been a memorable one in many ways, among which may be mentioned the following: The placing in operation of several large plants operating on straight high volatile coal in the new narrow Koppers oven; the decision on the part of Jones & Laughlin to build a 60-oven battery of the new triangular flued oven; increased use of benzols in motor fuel and in general industry; the successful conclusion on the part of the Koppers Company of a patent suit filed against the Wilputte Coke Oven Corporation and the Otto Coking Company for infringement of the Koppers cross regenerative coke and gas oven patent.

Previous to 1915 practically all Koppers ovens were built with an average width of 19¾ inches. After that date for the succeeding three years practically all ovens were built with an average width of 18¼ inches. All the ovens placed in operation in 1919 have an average width of 17 inches except those at Clairton. All the plants using this size oven are using straight high volatile coal with the exception of the Providence Gas Company.

Results from the use of these ovens have shown that the change to this type of oven has been fully justified. Not only are the yields of by-products higher than those anticipated, but the character of the coke shows improvement, the quantity of sponge and small coke being noticeably less.

In 1918 the Koppers Company placed in operation at St. Paul, Minn , a small battery of five newly-patented ovens, built with triangular flues. These ovens have shown conclusively that this type of oven is an improvement. The improvements are noticeably favorable in lower flue temperature for a given coking velocity, an improvement in the uniformity of oven heating, a complete cessation of any nozzle stoppages, and with these, a type of construction which undoubtedly means a greater stability and less leakage on account of decreased proportion of joints; and longer life.

At the present time, a battery of 60 of these ovens is building at the Jones & Laughlin plant, the construction of which has been viewed with favorable comment by engineers and operators from all over the country. This battery should go into operation in the early part of 1920.

The signing of the armistice left the producers of benzol in somewhat of a quandary as to what was to become of their product. Any doubts on this point have been quickly cleared away by the demand for these products in motor fuel for automobiles, for chemical industries manufacturing dies and pharmaceutical products and for solvents in all branches of industry such as paint and varnish manufacturing and the rubber business. The solvents commonly used in the past have been petroleum products. Benzol, toluol and solvent naphtha, both light and heavy, have many times the solvent power of the petroleum naphthas and these industries have been quick to find this out. It is apparent to all by-product coke producers that benzol and correlated products will find a ready market at high prices in the future.

In 1917 the Koppers Company charged the Wilputte Coke Oven Corporation and the Otto Coking Company with having infringed their Koppers cross regenerator patent No. 818,033. The lower court found the Koppers Cross regenerator patent to be valid and infringed by the Wilputte Coke Oven Corporation and the Otto Coking Company. The United States Court of Appeals upheld the judgment of the lower court.

Technical Progress of Coke Ovens Reviewed

By-product Coke Oven Development Divided Into Three Periods. Experimental, Short Coking and Present Period Discussed With Reference to Particular Installations.

By F. T. MORAN.
Superintendent By-product Coke Plant, Brier Hill Steel Company.

THE purpose of this paper is not to expound new theories of by-product coke plant construction or operation but rather by comparing, briefly, various plants at which the writer has been employed, to show the steady improvement and advances tending to reduce labor and maintenance costs.

The by-product coke plant as a department and an integral part of a steel corporation had its beginning with the building of the first Koppers ovens at Joliet for the Illinois Steel Company. Previous to this time various Solvay plants and Otto plants had been built and operated by the Solvay and Otto companies for the production of coke for steel companies. These were not at first operated as a part of the steel concern.

Following the example set by the Illinois Steel Company, various subsidiary companies of the United States Steel Corporation and many of the independent steel companies have placed the Koppers type of by-product coke plant in operation as an integral part of the company. At present the coke plant departments of the steel companies of America have a total coking capacity in excess of 40,000,000 tons of coal per year.

As my experiences have been with the Koppers type of plant, and as the Koppers type of plants built for steel concerns outnumber many times other types, this discussion will deal with the Koppers type only, and the general term of coke plant will be taken to mean the Koppers type.

Coke plant construction, beginning with the construction of the old Joliet plant, resolves itself into three periods: First period, the beginning or experimental period; second period, the short coking time period; third period, the present period.

The First Period.

The first period will include the old Joliet plant, Algoma Steel plant, Woodward No. 1, Gary, and Tennessee Coal, Iron & Railroad.

The period represented by these plants is called experimental; firstly because the Joliet plant was constructed upon the recommendation of the coke committee of the United States Steel Corporation after they had investigated at a great expense various types of ovens in Europe and America; secondly, the other steel companies of this country interested in economical production of coke were intently watching the operation of this plant and the resultant operations of the blast furnaces using the coke, and thirdly, because after such companies had built coke plants, improvements and changes came rapidly.

In the discussion of this period the old Joliet, Woodward No. 1 and the Tennessee, Coal and Iron Railroad plants will be used for discussion. The coal handling equipment of these three plants cannot be compared. The location, size and different operating conditions of each plant preclude such a comparison. The Joliet coal handling system with the addition of a car dumper would be equivalent to the coal handling of the Northampton plant of Bethlehem Steel Company, and to that of the Youngstown Sheet & Tube Co. The proximity of the Woodward and Tennessee Coal, Iron & Railroad plants to the coal mines, and the fact that they are not compelled to use a great many kinds of coal, make the handling of coal at these plants very simple.

In comparing the ovens, little change has been made in the brickwork and general arrangement of the ovens. On the standpipes a decided change for the better has taken place from the long centrally located standpipes of Joliet to the shorter standpipes of Woodward and Tennesse Coal, Iron & Railroad. The shorter standpipes located on the pusher side of the oven are easier to take care of, are not in the way, and eliminate one larry car and operator. In the alleys the greatest change is seen, from the tunnel like, oven like, mankilling allies of old Joliet we come to the open, cool and easily cared for alleys of Woodward and Tennessee Coal, Iron & Railroad. Here again there is a saving of labor and a greater saving of the morale of heaters and heater helpers. Next we see the passing of the continuous wharf of Joliet, with its dangerous swirling breeze laden steam along the whole length of the ovens, to the transfer-quencher car taking its steam with its breeze, and its danger, to a point away from the ovens. This change has worked a great saving in labor and removed a very dangerous condition. The original skip bucket, rotary screen type of screening plant of Joliet and Woodward compares very favorably with the screening plants of the latest types. The screening station of the Tennessee Coal, Iron & Railroad plant was not an improvement on to the by-product recovery portion of the plants; a retrogression, the original cost in comparison was enormous; the up-keep also enormous; and the improvement in the handling of the coke nil. Passing on to the by-product recovery portion of the plants, we have at Joliet the semi-direct type, producing both ammonia liquor and ammonia sulphate. At Woodward No. 1 and Tennessee Coal, Iron & Railroad plants the direct type of recovery was installed. As the market for sulphate of ammonia was good, this change, while one cannot say was an improvement,

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cut down the amount of apparatus to be maintained and operated by about one-half, and resulted in a material saving in labor and maintenance. In going from Joliet and Woodward No. 1 to Tennessee Coal, Iron & Railroad plants we find the positive exhauster replaced by the turbo exhauster. The superiority of these two types is still being debated.

The Second Period.

The second period may be called the short coking time period. This period is so named because at that time the theory was advanced that by increasing the size of the ovens, the flues, nozzles and air ports, and by carrying higher heats the coking time could be reduced to about 14 hours.

On this short time coking order Woodward No. 2, Republic, Maryland Steel and Inland Steel were built. The Lehigh Coke (Northampton plant, Bethlehem Steel Company) partially escaped this theory. It, however, suffered the transition changes from the second period to the third period. The idea of this period was that by enlarging and shortening the vertical flues, lowering the horizontal flues, putting in large gas nozzles, and large air ports, the oven chamber could be enlarged and the charge could be coked in about 14 hours. We believe the coking of the charge in 14 hours under these conditions was accomplished for a short time, but unfortunately the heats were run up so near to the fluxing point of the silica brick that it was dangerous. Then, too, this high heat so heated the evolved gases that carbon soon covered the walls and roofs of the ovens and even plugged the standpipes and goosenecks. On Woodward No. 2, the water-cooled standpipes were tried out. This type of standpipe was a great comfort to the workmen on the tops of the ovens, but owing to continual boiling over, stopping up and cracking, were at last filled with sand. It is believed that this standpipe was also tried out at the Republic Iron & Steel Co.'s plant. Its fate is not known.

On the Maryland plant we find in the McIntyre coke side door machine the first 100 per cent door machine. The first door machine on this order was designed for the Tennessee Coal, Iron & Railroad plant. This machine, however, could never be compared with the McIntyre machine for dependence and upkeep costs. The McIntyre machine with but few changes is giving 100 per cent service on the majority of the third period plants.

In the ovens of the first period, the clay jamb brick was tied into the silica liner; the difference in expansion, together with the abuse suffered by the jamb brick kept the first flue jambs continually leaking. It was impossible under these conditions to keep the leaks patched for any length of time. In the second period, the jamb brick was cut away from the silica liner and laid up against the end wall of the first flue in such manner that the expansion of the silica brick would take place without causing any large leak. This construction is still continued with very little leakage resulting. It was in this period also that the separate leveling door was discarded, and the present combined leveler and oven door adopted. The saving in labor, the elimination of leaks, burning and warping of buckstays, due to leaks from the separate chucks, were big items for economy.

The Third Period.

The third or present period covers such plants as were built during the recent world war. The war was the cause of the greatest development ever experienced in the coke oven industry. Plants were built almost over night. The reason for this extraordinary expansion was the enormous demand for the by-products, benzol for explosives, dyes, toluol, xylol and sulphate of ammonia for explosives.

During this period the idea of fast carbonization for production of coke was given up. The design of the ovens was slightly changed to fit the demand for maximum production of all products. The horizontal flue was raised and its area cut down. The vertical flues were narrowed and the air ports cut down. The thickness of the oven walls was cut down. The width of the oven chamber was decreased slightly to allow faster coking at a lower temperature. The idea of this last change was to increase the yield of by-products and still retain maximum speed in obtaining good metallurgical coke.

For the ovens of the second period the high heat necessary for fast coking set up a zone of intense heat through which the evolved gas laden with by-products must pass, and in so passing broke up, reducing the yields. With ovens of the third period the heat zone is at least 500 to 600 degrees F. less than in the second period ovens, and owing to ease of heat regulation the hot top characteristic of the second period ovens has been replaced by the cold top with an increased yield of by-products with no appreciable decrease in tonnage of coke per oven.

In this period, owing to the operators and constructors working out their problem together before constructing the plants, great strides have been made in eliminating labor and in easing the lot of all labor employed about the plant.

The coal handling plants have been equipped with a central electrical control. The various pieces of machinery and belts are so interlocked as to prevent the failure of any one unit from effecting any of the others. The coal handling plant of the Youngstown Sheet & Tube Co. is an excellent example of the ease of operation with a minimum of labor. Other plants have equally as good coal handling systems but some are not large enough to afford so complete a layout, or they have conditions that are materially different.

On the ovens various types of gas dampers have been installed which are accessible for cleaning and repairs. Most of the larry cars are now installed with the electric standpipe swab, developed at the Youngstown Sheet & Tube Co.

The larry cars are arranged to discharge coal with almost no spill about the charging holes. Tar seals, etc., are arranged so as to need scarcely any attention. Coal drawn out by the leveler bar during leveling is caught in a box attached to the pusher, emptied into a small hopper, conveyed to top of the battery and into the larry car without the touch of a human hand. It can safely be said that the labor involved has been cut at least one-third, and that the laborer, himself, on one of the present type of ovens, does not work half as hard as on the older type.

The coke handling plants have been so arranged that the coke is very carefully handled. Every possible fall has been eliminated. The various belts, screens, etc.; are tied together electrically to eliminate spills and accidents of all sorts. The only real labor done on these plants is the cleaning up of dust and scattered pieces of coke.

The by-product house has been constructed to operate with the least attention; various changes have been made in the different pieces of apparatus. Some changes have not been altogether successful but the tendency has been to reduce labor, material and upkeep costs.

The benzol plants came into existence during this period. Many changes in apparatus and operation have developed in the few years of their existence. As an example of the numerous changes made at the Brier Hill plant and as an indication of the many changes made at other plants, F. D. Schreiber, of the Brier Hill Steel Company, last year developed the use of lime to replace caustic soda, a great economy at that time. This has been discussed by Mr. Schreiber in January 1, 1919, issue of the *Gas Age*.

By-Product Coke Plants Await Development

Offer Unlimited Opportunity for Research and Study. Use and Development of New and Existing By-products. Use of Gas in Gas Engines Offers Further Possibilities.

By G. T. WILLIAMS
Assistant Superintendent By-product Coke Plant, Brier Hill Steel Company.

The author of this article suggests the unlimited possibilities of further investigation regarding the use of by-products and indicates that at some future date it is conceivable that steel companies may so develop their coke plants as to take care of their own demand for pickling chemicals, paints and protective coatings.

THE statement has been made that there has been no great basic discovery or invention in the method of carbonizing in by-product coke ovens in the past 20 years. We have today practically the same narrow horizontal retort as first built. However, the design has been improved on and the various changes, I believe show a way to the future development of the coking chamber.

First we had the increase in size of the oven for greater capacity, but in late years we have been working toward a narrower oven, with the idea of getting a maximum tonnage of good metallurgical coke with a minimum of heat applied which has materially increased the yield of by-products by decreasing the temperature of the zones through which the gases must pass in leaving the oven.

The control of this temperature is the goal that future developments will work toward and a radical change in the methods and the point of applying the heat would not be surprising. We do not have to tax our imaginations greatly to picture an oven of such shape and dimensions to allow the heat to be applied underneath the charge and the gases drawn from above.

The continuous coke oven which has received much thought may also be developed in connection with such a scheme.

In our by-product recovery apparatus the well known processes remain the same but the mechanical structures are being continually refined to lower upkeep costs.

Controversy still exists in regard to the size and shape of ammonium sulphate saturators, and we appear to have increased our upkeep cost by increasing the size without increasing the capacity of the saturator in proportion.

Recent developments in pumps especially tar and liquor pumps have been welcomed by the operator for their steady and continuous operation.

We cannot do much to increase efficiency of the processes now in use but future designers can lower initial and upkeep costs by mechanical refinements.

The use of our products and the development of new by-products offers unlimited opportunity for research and study. The gas is becoming more and more valuable as the steel maker uses it for his highly finished products and our cities learn its value for domestic use. There is much work to be done in its use in gas engines.

We are recovering our ammonia as sulphate and aqua ammoina and it may be to advantage to perfect a simple process for ammonium chloride which is used by many steel works themselves in pickling processes. Cyanides are neglected in our plants for lack of markets but present opportunities for the future. We have the necessary components for our sulphuric acid in the gas awaiting a simple process of recovery.

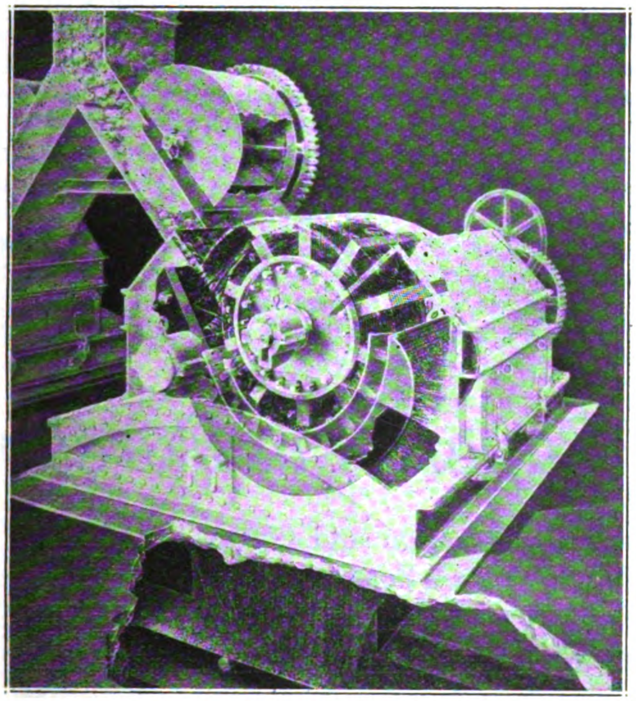
Chemically then the by-product plant has large resources awaiting development and in the future the steel works may so develop their by-product plants as to take care of their entire demand for pickling chemicals, paints, and other protective coatings for their products.

Crushing Coal in By-Product Coke Industry

Crushing of Coal Plays Important Part in By-Product Coke Plant Economies — Phantom Views Show Operation of Modern Type of Crushing and Washing Apparatus.

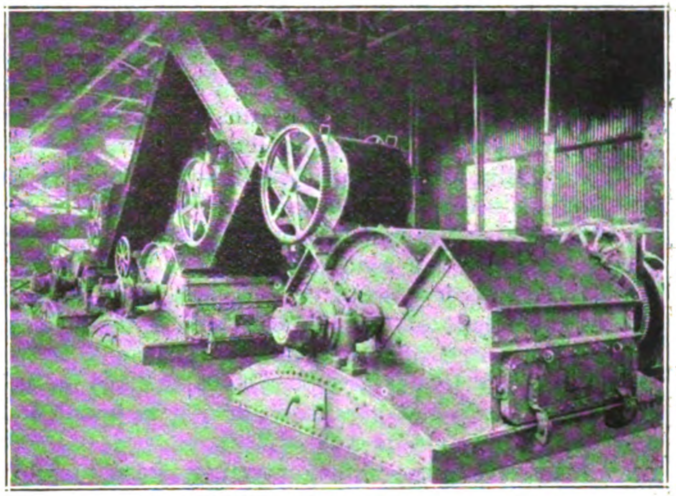
ANY attempt to reduce to figures the value to the country of the by-product coke industry at the present time gives the imaginative mind very little satisfaction. The uses of many of the most valuable by-products are in their infancy and the economic needs of the country are in a state of extremely rapid change, so the computing of what is now saved out of what a few years ago was wantonly cast to the four winds is no real gauge for the future.

The part played by the by-product coke industry in the country's recent industrial development, suggests its future better than any amount of statistics. For international trade in which success depends on the possession and efficient use of natural resources, a continent or a country without coal must remain forever in a subordinate position, and, per contra, where coal is, there lies the greatest opportunity for industrial supremacy.



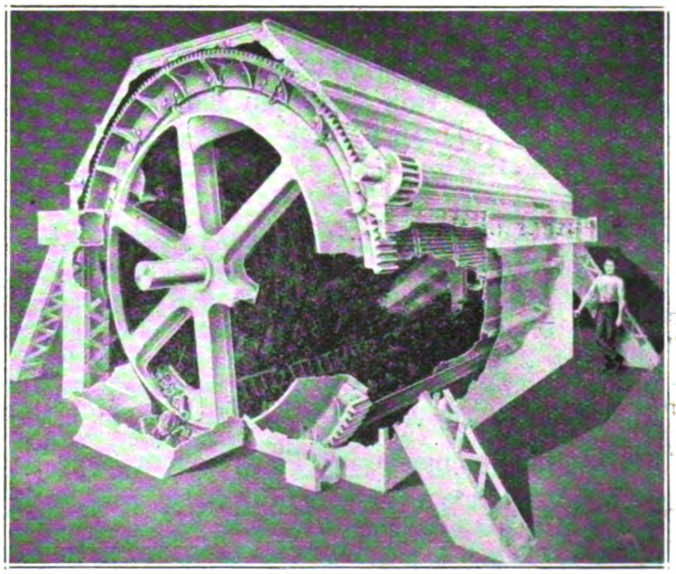
Phantom view of crushing apparatus.

For a great many years it looked as though the opportunity of a large coal supply had been given this country only to be thrown away in wasteful practices, but the rapid development of by-product coking has changed all this. It has made the commercial future far brighter. The inestimable value of the by-product coke oven is becoming known to an ever widening circle in industry and the spectacle of beehive coking which, a few years ago aroused no particular sensations in the great majority of observers, now means something very serious and fateful to the same people. Other misuses of raw coal as a fuel cannot long escape the same pressure of opinion which will mean their gradual abolition.



General arrangement of crushing plant.

All things considered it seems hardly likely that the sweeping advance of the by-product coking industry will be greatly checked by the change from war to peace demands. In organization equipment and methods it has the atmosphere of an army swiftly on the march to take a well-understood objective. It is almost safe to say that never has a new and revolutionary industry faltered so little at the outset.



Phantom view of washing apparatus.

The early days of electricity afford an excellent

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comparison. Fifteen years after the first commercial adaptations, the electrical industry was still in a most primitive state. Large producing units were in the dim and distant future. Instead flocks of small dynamos sputtered away and miles of whipping belts sputtered back. Inefficiency invited bankruptcy and the invitation was often accepted.

Compare this with the by-product coke industry in which, installations made only 15 years after the first by-product ovens in America, not only are operating successfully but still rank among the large and efficient installations. Where were the old dynamos 15 years after the condition of the industry above pictured, and again, where now are the big cross compound engines and generators that succeeded them? It took 40 years in the electrical industry to reach a state approaching stabilized design. Except for minor changes, by-product oven design reached maturity in 15 years and so will have had 25 years of refinement and development free from radical experiment and change by the time it is as old as the electric generator now is.

The usual equipment for preparing the coal consists of two types of machine, and both have reached a high state of development in design and construction at the hands of the Pennsylvania Crusher Company. The first of the machines is the Bradford breaker which is usually placed at the top of the crusher house in batteries of from one to four, to receive the run of mine coal. This machine consists essentially of a large slowly rotating drum having a steel frame of great ruggedness, covered with a shell of perforated plates. The coal enters at one end and is carried up by longitudinal shelves on the inside of the drum, and as each shelf passes the angle of repose the coal drops and breaks, the smaller pieces passing the perforations and the larger ones being caught by the next shelf and dropped again. The contents of the drum are pushed steadily along by the screw action of rows of heavy steel deflectors bolted to the inside surface of the drum, each one catching its share of the load at an angle and thrusting it along. By the time the far end of the breaker is reached there is little left inside but slate, rock, sulphur balls, tramp iron, mine timber, etc., and this refuse matter is pushed out to the mouth of the chute by the helical action of large plow castings which resemble sections of a huge screw thread. The machine moves as a unit structure and requires comparatively little power, delivered through the pinion and gear.

From the breaker the coal is either stored or delivered direct to hammer crushers which also are arranged in batteries of from one to eight.

The strenuous nature of the service requires brutal structural strength, and the requirement is met by heavy steel construction.

The dynamic qualities of this swiftly rotating machine are directly the opposite of the slow-moving breaker. Rows of steel hammers traveling at high velocity subject the coal to a terrific milling and deliver a pulverized product from which the tramp iron has been automatically removed, ready for the ovens, at a controllable rate which reaches a maximum of 400 tons an hour in the largest of the Pennsylvania hammer crushers. It is safe to say that in no feature of a modern coke oven plant is the thorough-going design and construction which leads to complete reliability of service better exemplified than in the crusher house. The illustrations shown are phantom views of a crusher and a breaker manufactured by the Pennsylvania Crusher Company.

American Coke Plants Superior to Foreign

Comparison of By-product Coke Oven Construction and Operation Between European and American Practice—Foreign Plants Not Far Advanced and Hampered by Labor Conditions.

By J. I. THOMPSON.

THE author of this article visited European industrial centers some months ago together with A. W. Grant, Jr. He was particularly interested in a study of European by-product coke ovens and the following discussion taken from a paper read by him before the Engineers' Society of Western Pennsylvania is of considerable interest.

Mechanical Equipment and Plant Layout.

American practice in this regard is distinctly superior. Our equipment is more rugged and more reliable. The new plants which we visited in Europe, although better in every way than those built before the war, are not comparable with American practice of the past few years.

The multiplicity of units to handle a small tonnage is very noticeable. We visited a plant in France which will carbonize about 2,400 tons of coal a day. It was composed of six batteries of ovens arranged, not with a common centerline, as is our custom, but each battery separate, with parallel center lines and individual coal bins. This necessitated a pusher machine for each battery, two coal charging cars for each battery—the gas collecting main being in the center of the battery—and extensive duplication of coal and coke-handling equipment. When one considers that the shortest possible coking time in this plant was 24 hours and the normal time 30 hours, giving a pushing schedule of 35 to 45 minutes for each machine, it is evident that this arrangement is the cause of a great waste of equipment and labor. A modern American plant of this capacity would be equipped with one coal-bin, instead of six; two combined pushers and levelers in operation, instead of six; one coal charging car in operation, instead of 12. It would contain two batteries of about 60 ovens, instead of six of 42. In England, we visited a plant similarly arranged constructed during the past few years by another builder. Of course, not all the plants were arranged in this way. We visited a new plant in Wales which was just ready to be put into operation. The details were carefully thought out, and the construction work beautifully executed. The nominal capacity is about 1,200 tons of coal a day with a coking time of about 26 hours. For such a small capacity, we were impressed with the excessive amount of equipment provided. The plant is composed of 120 ovens, split up into four batteries of 30 ovens each, arranged in one line. With the larger ovens and the shorter coking time obtained in this country, such a capacity would be conservatively obtained with 70 ovens which would be constructed in one or perhaps two batteries.

There is one point I wish to emphasize, which is true of the by-product coke oven plants in all the countries visited. The cost of these plants, assuming the same unit prices for labor and material, must be considerably higher per ton of coal carbonized than similar plants as designed in this country. If for no other reason, the long coking time which reduces the capacity of European ovens, as compared with American ovens of the same volumetric capacity, must add greatly to the cost of construction.

I was very much interested in noting the extreme care with which coal is handled, particularly in some of the collieries in Belgium. The mining of bituminous coal in France and Belgium is very different from the mining operations with which we are familiar. The mines are very deep, many of them over 3,000 feet below the surface. The coal is relatively very much more costly at the pit mouth, and, as a consequence, it is mined and handled much more carefully than in America. Practically all the coal is carefully screened and washed. The larger sizes are sold at higher prices for special purposes, and only the very fine material is used for coking. The slurry and fine coal are also made into briquets, which are used quite extensively for locomotive firing on the railroads. We were told that an ordinary guarantee for a coal washing plant was 2 per cent ash with a loss of about 2 per cent of good coal in the washery refuse. The ash content before washing was in some cases, as high as 15 per cent or more, which would make the coal useless for coking purposes without washing. In the plants we visited, the washing water was used over and over again, thereby avoiding the contamination of streams with waste water. Draining bins seemed to be the common method of drying the coal.

The coal washing plants in Europe impressed the writer very favorably. They were clean to a remarkable extent. In fact, it seems to me that European engineers have progressed much further in the art of washing coal than in the art of coking it.

We have much to learn from Europe along the lines of conservation. As our rich gas coals and coking coals become scarce, and therefore more valuable; as our mining costs increase, due to the increased cost of labor; as freight rates increase, making it unprofitable to ship fuel with high ash content; and as the consumer realizes the economics which may be effected by the use of a cleaner and more uniform fuel, we will be forced to adopt European methods of conserving coal.

Most of the coal is crushed in jaw or roll crushers and pulverized in disintegrators. These disintegrators work very well for small capacities. We did not see any hammer mills such as we use so extensively in this country. Where coal is mixed it does not seem to be so carefully mixed as is our practice. Belt conveyors are used for handling coal, but not so extensively as in American coke plants. Perhaps the development of the apparatus used in this country for the handling of coal and coke is largely the result of the large capacities of most of our plants as compared with those of Europe. The largest plant we visited carbonized about 2,400 tons of coal, while a plant of 1,200 tons capacity is considered a fairly large one. It would be practically impossible to handle the tonnages to which we are accustomed, with the ovens and the apparatus in use in Europe. The general practice in Europe is to push the coke out of the oven, through a coke guide composed of perforated pipes, on to an inclined wharf extending the full length of the battery. From this wharf it is either forked by hand into cars—the forking operation taking the place of mechanical screening—or it is fed through gates, extending the full length of the wharf, to a steel pan conveyor which conveys it to a screening station. Quenching immediately in front of the oven was abandoned several years ago in this country, but we did not see a plant in Europe with a central quenching station.

It is not necessary to point out to American operators the disadvantages of this system. Quenching is a dirty operation, at best; and with the system in use in Europe it is not possible to provide for conveying the steam away from the ovens and the immediate vicinity, or to dispose properly of the waste water and its entrained coke dust. In cold weather this method of quenching is especially objectionable. A central station is much cleaner and gives greater uniformity of quenching. The continuous wharf of massive, arched concrete or brick construction, covered with cast-iron plates and equipped with feeder gates the full length of the battery, is very expensive; and steel pan conveyors are not suitable for handling coke, due to the abrasive action of the coke on their many moving parts.

It seems to the writer that this choice of coke-handling equipment is largely responsible for the extensive duplication in the equipment used. One of the plants previously referred to, which we visited, had a capacity of approximately 1,800 tons of coke and was equipped with three steel pan conveyors, each conveyor located between and serving two batteries of ovens and delivering coke to individual screening stations. The first cost, maintenance, and labor cost of such appliances must be excessive. For the same service we would employ a single wharf instead of six, and one conveyor and central screening station instead of three.

Some of the most modern plants abroad, are equipped with a large coke screening and loading machine, which travels on rails in front of the ovens. The quenching is done directly in front of the oven—while the coke passes through the coke guide—by means of a water spray formed by forcing water through the perforated pipes of which the coke guide is constructed. The coke then falls on an inclined wharf which runs along the full length of the battery, and a large percentage of the quenching is done by hand on this wharf. Gates are provided at the lower end of the wharf throughout its entire length to discharge the coke to a large steel bucket elevator which is mounted on the machine and which delivers the coke to a bar screen which terminates in a chute to the cars. The breeze and small coke pass through the screen into cars which are placed directly under the machine. Such a machine could not easily be supplied where several sizes of coke are to be produced. It is an improvement over the pan conveyors which I have just described, because it makes it possible to handle the coke with machinery and construct several batteries in one line and thus economize in pushers, coal bins and charging cars. It does not, however, eliminate the objectionable feature of quenching in front of the ovens.

In Belgium, coke-handling apparatus has seldom been installed. When coke can be forked by hand from a wharf into cars for an equivalent of four cents a ton (which was the cost before the war) it is hardly to be expected that mechanical equipment will be installed to do the work. Such labor rates are a thing of the past and mechanical equipment will undoubtedly be required in the future.

There is no radical difference between the by-product apparatus of the several types in common use in Europe and similar types in this country. In this department of the work, as in the others, no effort seems to have been made in the newer plants to skimp the apparatus either in quantity or quality.

Coking Time.

In our visits to coke plants the question most often asked by managers and superintendents (second only to inquiry regarding our labor situation) had reference to the short coking time prevailing in America. In England, France, and Belgium, designers and operators of by-product coke-ovens cannot understand why the normal coking time of American ovens averages only about 60 per cent of the normal coking time for ovens of the same average width in Europe. We have found it very difficult to explain such a great difference, to European engineers and operators, as being due to improved methods of construction and operation; but I am convinced that this great difference can be accounted for in no other way. Briefly, and without going into technical retail, the following are the most important explanations:

It is the practice in this country to use silica material in by-product coke-oven construction. Some English firms were experimenting with silica walls in old batteries that were being repaired, but this will hardly be a fair test. I think there is not a single battery of ovens in England, France, or Belgium constructed of silica brick—the material used ranging from what we would term fireclay up to quartzite, with a maximum silica content of about 85 per cent. The fusing temperature of silica brick is higher than the fusing temperature of brick such as they use; but more important still, the softening point under load is 500 or 600 degrees F. higher for silica brick than for fireclay or quartzite brick. Temperatures as high as 2,700 to 2,750 degrees F., which we maintain in the heating flues without injury to the brickwork, cannot be obtained with material of lower silica and higher alumina content. For this reason, there is much greater safety in operating a battery of ovens composed of silica material. The walls of the heating flues may be at the fluxing temperature before they will fail, but a clay brick wall will soften and deform under its own weight before its fluxing temperature is reached. Silica material also has greater conductivity, which, added to the much higher temperature head available, makes it possible to transmit the requisite heat through the walls and into the coal in a much shorter space of time. Silica brick expands to a greater extent than fireclay brick, but it has the convenient quality of continuous expansion at all temperatures up to its softening point. Fireclay brick, however, expands up to about 2,000 degrees F. and then contracts. It is practically impossible to keep coke oven construction gas tight under such conditions. As expansion takes places, the tie-rods and buck-stays can be loosened, but tie-rods and buck-stays will not close the joints opened up by contracting brickwork.

The next consideration—and of equal if not greater importance—is uniformity of operation. Coking operations are much more uniform in this country. A good operator here will fix the coking time to meet the coke or gas requirements within the limits of the capacity of the plant and insist on absolute regularity of pushing. The men responsible for the heating must see that the coke is ready to be pushed at the scheduled time. Such regularity of operation is not obtained in Europe. Either the plants which we visited were not properly operated, or their design and construction are such that they could not be properly heated. The heats were generally not uniform.

Gas pressure regulation in the ovens does not receive the careful attention that we give this feature. We visited a new plant in which gas exhausters were to be driven by a motor through a line-shaft with no means of regulation except by operating, by hand, a gate-valve in a by-pass line around the exhauster. Nowhere did we see any serious attempt to control the gas pressure in the oven chamber. With leaking walls and wide ranges of pressure within the ovens it is impossible to obtain good heating. It is not putting the case too strongly to say that we did visit a plant in which the gas was poorly burned and the ovens uniformly heated.

The only explanation for the greater speed of American ovens is to be found in the details of design, the materials used in the construction, and the more uniform and scientific operation.

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Blast Furnace Department

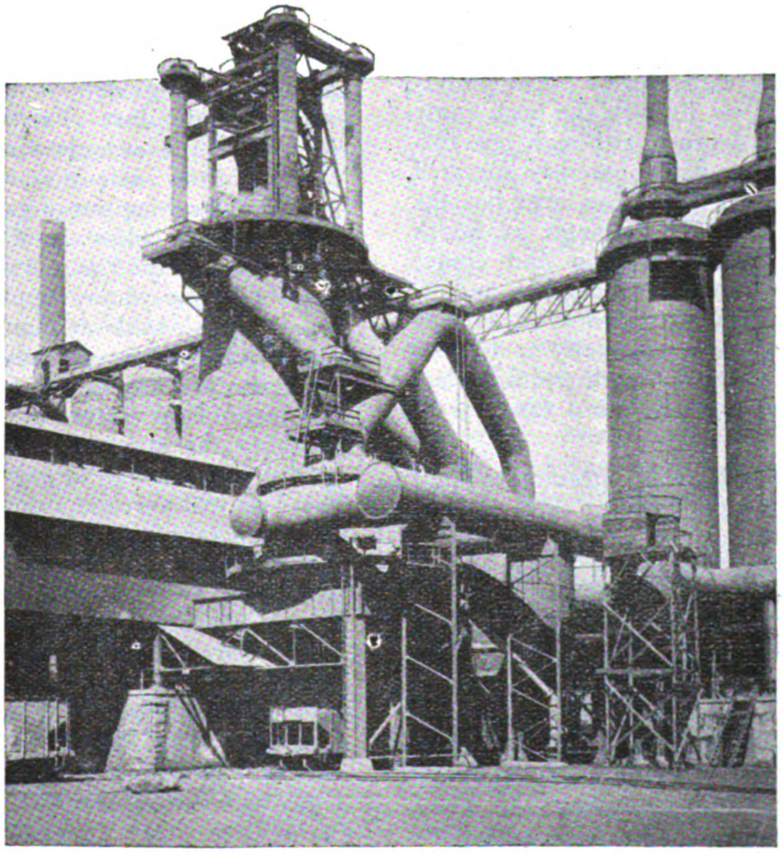
DURING the past year blast furnace activities although notable were not as active as during the war. Production and new construction materially fell off. Technical developments were not startling although considerable progress was made. The articles in this section throw considerable light on the technical progress of the year.

That foreign countries are looking toward America for modern methods is indicated by the active part taken by American engineers in the design and construction of the new blast furnace plant of the Indian Iron & Steel Co.

Gas cleaning received a great deal of attention, and the tendency in this direction seems to favor dry cleaning.. The Kling-Weidlein dry cleaning process has been eagerly accepted and much attention is being given the electrical precipitation process.

Another interesting phase of activity in the blast furnace field is the intelligent rebuilding of blast furnace plants to increase production and to further economy in operation.

During the year about 400,000 tons of annual pig iron capacity was added to the existing capacity. In excess of 2,000,000 additional capacity is at present being added in blast furnaces now under construction.



Blast Furnace Development During 1919

Abnormal Economic Conditions Greatly Influence Blast Furnace Operation—Furnace and Stove Equipment, Boiler Plants, Blowing Engines, Coke, Gas Cleaning and Stack House Arrangement.

By **HARVEY W. LINHARDT,**
Indiana Harbor Works, Inland Steel Company.

IN reviewing the technical developments and progress in blast furnace practice for the past year, it should be borne in mind that it has been a period during which unusual conditions obtained.

Furnace practice with but few exceptions throughout the country has not been meritorious as far as records are concerned. This has been mainly due to very inferior coke. The customary or preferred kinds and normal grades of coal have not been available in either quantity or quality for the coke man and the product has been a coke high in braize and ash content, and very weak structure. Many of the operative troubles of the past year are easily traceable to this source. It has been a year that has called for the closest coöperation between the blast furnace operator and the coke oven operator.

Under furnace design, we may say there is a tendency toward the revolving top on new construction, with less clearance between large bell and stockline, increasing the angle of deflection of inwall and medium thick linings. Laying the face brick of the lining in high temperature cement is advocated at some plants and is meeting with success. The preferable number of tuyeres is 9 or 10 with the bosh angle in the neighborhood of 80 degrees, although one furnace in the Mississippi Valley has apparently operated successfully on an 83 degree angle. The large hearths have still to surpass the 20′ 9″ diameter at South Chicago. The angle between the iron and cinder notches is still generally between 45 degrees and 90 degrees and presumably the only attempt to date to put into effect the idea of spacing equally at 120 degrees apart, the iron notch, cinder notch and hot blast intake is in the design of the new Ford furnaces at Detroit.

Until recently there has been an attempt to limit the hot blast equipment to three stoves. With washed gas and the increased heating capacity of the stoves due to smaller checkers, this number of stoves should be adequate providing the length of service of the stove be obtainable to the extent that we have been accustomed to it in the past which was from 10 to 15 years. But there have been a sufficient number of failures of stove linings in the past year to question the advisability of limiting the equipment to three stoves. For this reason the newer plant layouts call for four stoves for a single furnace plant and seven stoves for the two furnace plant with the middle stove equipped with valves for operating on either furnace. The real cause of the failure of the stove linings has not been determined. Whether it is due to reduced thickness of walls, poor workmanship, quality of clays used or percentages of mixtures, remains to be proven. We do know, however, that there have been changes in the percentage mixtures of the clays. As to type of stove, we may say that the two pass side combustion answers every requirement. The low stack temperature of 400 degrees F. and under, that is obtained on the modern two-pass stove obviates the use of the three and four pass type of stove. Ease of operation and low cost of repairs also favor its installation. One of the later stove appliances that is proving to be a valuable acquisition and is being well recommended is the Mathesius hot blast valve.

The subject of gas cleaning has been intensively discussed, volumes have been written about it and it is only proper that a matter which is of such vital importance to the blast furnace manager should be given prominent consideration. There is no argument as to whether or not blast furnace gas should be cleaned. It is only a question as to what means should be adopted for cleaning. The dry whirlers have been a help in removing flue dust. In the majority of cases, however, they have simply acted as secondary dust catchers, taking out of the gas only the coarser particles of the dust. Far superior to this form of dry cleaning is the wet cleaning or wet washing of gas. With a little attention to water regulation and periodical washing out of gas mains, the solids are consistently kept below .2 of a grain per cubic foot of gas. This method is particularly adaptable to locations of ample water supply. On the other hand, it is not objectionable at plants where the water supply is not so plentiful because precipitating or settling arrangements may be provided which will recover not only most of the water but practically all of the sludge. Probably the strongest objection that can be raised against wet washing of gas is the loss in sensible heat. This loss will average around 5 per cent. Considering the temperature of the gas leaving the top of the modern furnace as about 300 degrees F. and with a plentiful supply of the gas, the loss of the 5 per cent in sensible heat due to wet washing becomes negligible when compared to the greater stove and boiler efficiency and economy and lower cost of labor. There have been numerous installations of wet washing systems of the Brassert type during the past year. Attempts have been made from time to time to obtain a gas as clean as the wet washed and have it retain the sensible heat, by passing the gas through some filtering agent such as steel wool. The first dry cleaner of this type was built at the Ohio Works of the Carnegie Steel Company at Youngstown, O. The method is patented today as the "Kling-Weidline Dry

Cleaner" with recent installations at the Brier Hill, Cambria and Crucible Steel plants. The late designs of this cleaner call for superimposed inlet and outlet gas mains with the gas being passed through a single filter 18 inches thick composed of three beds of steel wool. The cleaner is built in any number of compartments or stages depending upon the duty to be performed. Each compartment is independent of the others and can be opened for inspection with safety while the remaining compartments are in operation. The designers claim for this cleaner a 95 per cent recovery of the flue dust with 52 per cent of same passing through a 200 mesh sieve. The screens are vibrated automatically at specified intervals under control of a time gear. An attractive feature of this installation is the simple and safe quick acting explosion door specially designed for and liberally applied to the cleaner. Another process that has been experimented with for some time is the Cottrell system of electrical precipitation. We know this system is highly successful in handling the smelter fumes from the reduction of non-ferrous metals and in cement manufacture. We have looked forward to its handling blast furnace gas with the same degree of success, because we believe it embodies the correct theory in cleaning blast furnace gas, in that it is a force precipitator instead of a mechanical separator. This patent is controlled by the Gellert Engineering Company of Philadelphia and at present has an installation at the plant of the American Manganese Company at Dunbar, Pa. This furnace has been operating on ferro-manganese, which is synonymous with a heavy fumed colored gas. The extraction of the gas by this process is sufficiently complete to remove the color from the gas. A further visible evidence of the high efficiency of this process is obtained in the exceeding fineness of the dust recovered. While the Cottrell system may be subject to some improvements for taking care of heavy furnace slips, and these improvements no doubt will be provided; under normal furnace operation, this process should prove to be the coming gas cleaner. It should be of particular value when gas blowing engines are used. Further, it not only affords a means of alkali recovery but by this recovery it eliminates one of the sources of brick deterioration in the stoves.

The modern boiler plant is being provided with the larger units of the standard makes, such as Sterling and Babcock & Wilcox. The preferable size is around 800 hp per boiler at 225 pounds pressure and 125 degrees superheat. Although boilers are being built up to 2,500 and 3,000 hp and are satisfactory for electrical power plant purposes, this size is not adaptable to blast furnace work. Boilers of 1,250 hp have been installed for this work, but this size is not advisable, ~~for the reason that~~ if one boiler is off on a 5,000 hp boiler plant installation, it means a drop of 25 per cent in boiler capacity. It is also advisable on new installations to erect the high pressure pipe lines as the initial cost of the higher pressure lines is comparatively little more than the cost of low pressure. Also, future plant extensions and additional blowing equipment are apt to demand it.

With the subject of blowing engines, we bring up a much mooted subject. There are three distinct types of blowing engines; the steam reciprocating engine, the turbo-blower and the gas engine and each type of engine has its supporters and adherents. Space does not permit me to review the arguments that have been offered at times by those favoring any one of the types of blowers. In brief, we may say that the steam reciprocating engine has always been claimed to be the positive blower. This position has been greatly strengthened through the introduction of the plate valve like the Rogler and the Iverson. This improvement in the air end not only eliminated a great source of trouble due to the old style valves, but also made it possible to increase the speed of the engine, resulting in the much more efficient high speed reciprocating engine of today. This engine is meeting with great favor. On the other hand, probably the one criticism that had been presented more than any other against the turbo-blower was its non-positive delivery of air or surging. In overcoming this defect, the builders of turbo-blowers have made wonderful strides in the past two years. The turbo-blower has these advantages over the reciprocating engine,—a cheaper installation including the smaller foundation, requires less space, less upkeep, fewer operating men and considerably less oil. It is an interesting fact that the Oxford Furnace Company at Oxford, N. J., one of the pioneers in the use of turbo-blowers is replacing its present small units with larger turbo-blowers that have been in use for 10 years with complete satisfaction at another blast furnace plant. This is certainly a record that speaks well for turbo-blowers. The gas engine is rather in a class by itself. It has proven its economy and high efficiency, but it is primarily a large plant engine, where ample gas supply is assured at all times and the gas is furnished to the engine in a thoroughly cleaned state. The installation of this engine is advisable where a gas credit is desired by the blast furnace department or in other words, where power is to be supplied to some other department.

New stock house installations are generally of concrete bin construction with either the revolving drum or hand lever type of gates. Both types of gates have good points and both types require additional labor with wet or frozen ores. The skip engines are mostly electrical, driven with a few ac current types. The coke bin has always been a matter for local decision. The coke is still being "shot" or measured to take care of variations in moisture content and to facilitate the time for charging. Also the coke is being weighed where actual weights are being sought. But the weighing of the coke is usually accompanied by such clouds of dust that accurate weighing becomes difficult and provides the opportunity for questionable results. Again the weighing of coke is not advisable when there are wide swings in the moisture content of the coke.

In conclusion, we may say that probably the most modern all around new blast furnace plant that has been put in operation during the past year is that of the Weirton Steel Company at Weirton, W. Va.

American Engineers Design New Blast Furnace Plant for Far East.

Indian Iron & Steel Co., Ltd., Calcutta, India, Now Erecting Three Hundred and Fifty-Ton Capacity Blast Furnace, Together With One Hundred and Sixty-eight-Oven By-Product Coke Plant.

THE development of the iron and steel producing industry in the Far East has made large strides during the past decade and that this progress is not at a standstill, is evidenced by the recent entrance of a new company into the iron producing field of India.

The Indian Iron & Steel Co., Ltd., of Calcutta, India, with Burn & Co., as managing agents, was formed in the early months of 1918, for the purpose of utilizing iron ore and coal properties which had been prospected and acquired. These ore and coal properties showed such promise that during the latter part of 1918, it was decided to build the first unit of a complete plant at Asansol, India, a town located on the East India Railway about 120 miles north of Calcutta. This location was chosen on account of its proximity to the coal fields.

Under the managing directorship of G. H. Fairhurst, preliminary work was completed and contracts were entered into for the construction of one complete 350-ton capacity blast furnace together with a 168-oven by-product coke plant.

Simon-Carves, Ltd., of England, received the contract for the construction of the coke plant and Arthur G. McKee & Co., of Cleveland, O., were selected as engineers and contractors for the construction of the blast furnace plant. The work of designing was started during March, 1919, and shipments of materials were started during April. At the date of this writing approximately 85 per cent of the materials of construction have been started overseas and the balance will probably be on ship board before the end of the year.

During September of the present year, the Indian Iron & Steel Co. decided to further increase its capacity and accordingly orders were issued to proceed with the construction of a second blast furnace of similar design to the first.

The layout of the completed plant provides for the ultimate installation of six blast furnaces, each of 350-400 tons capacity, sufficient coke plant capacity to pro-

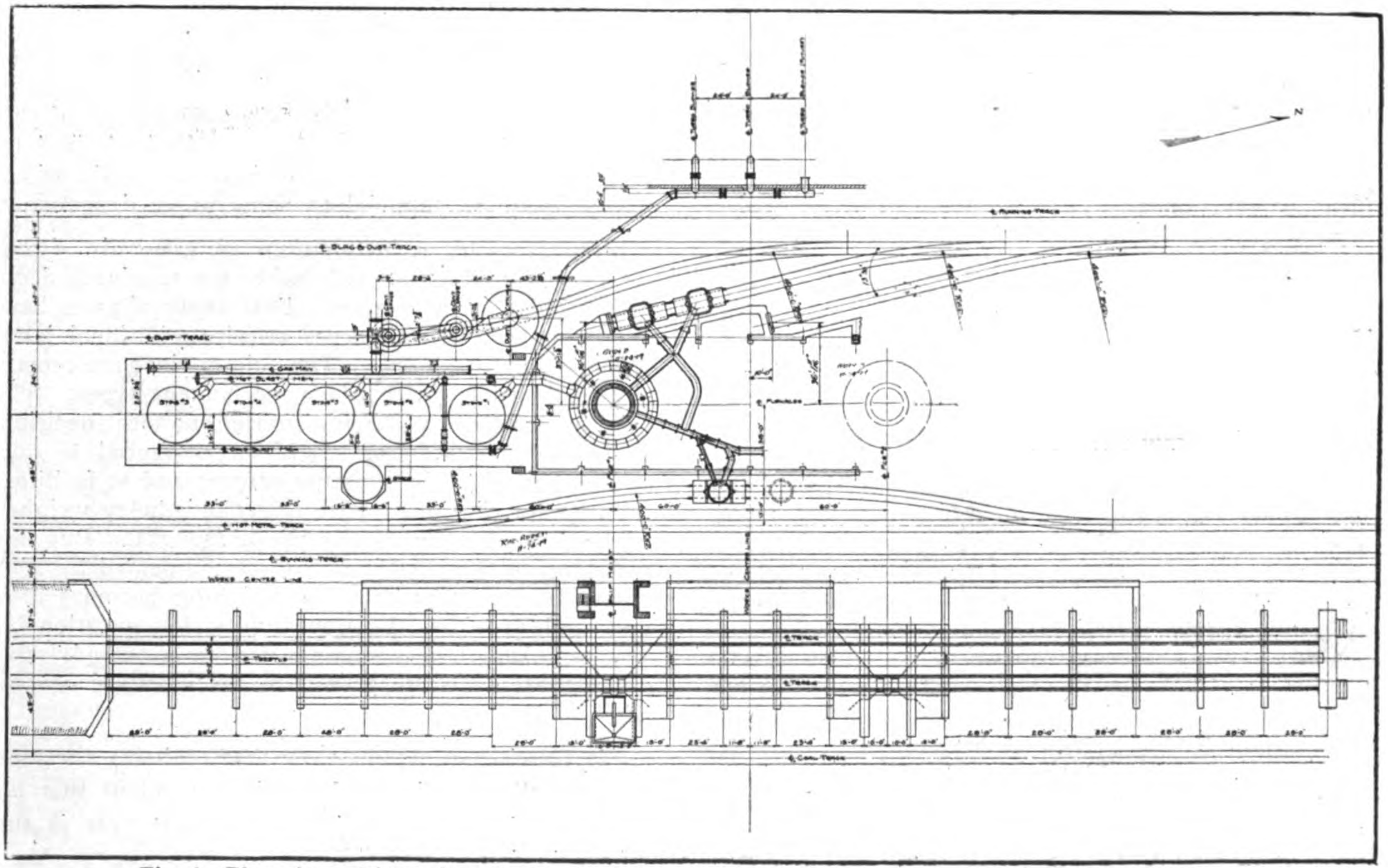


Fig. 1—Plan view of blast furnace plant being built at the Indian Iron & Steel Co., Calcutta, India.

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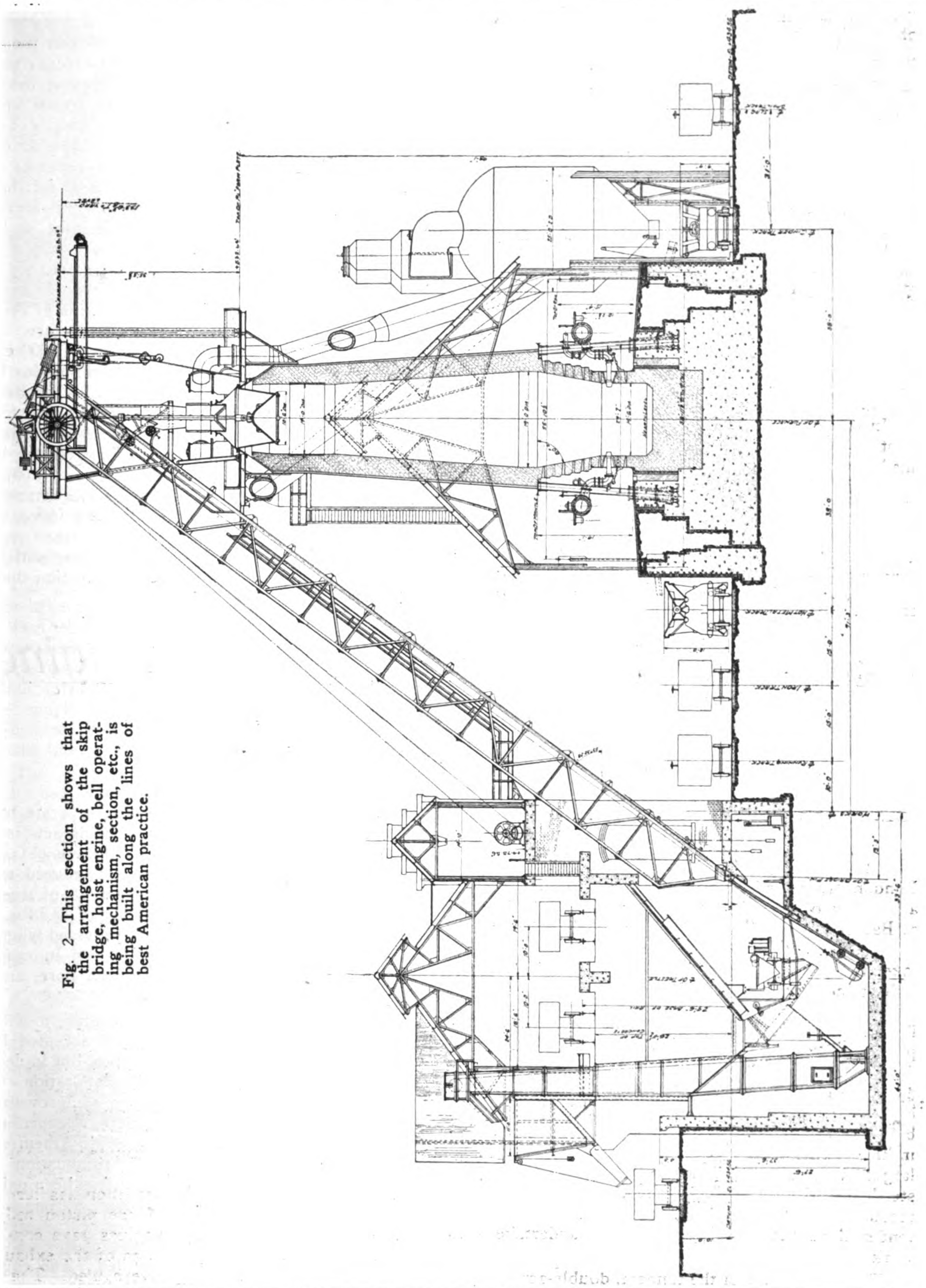


Fig. 2—This section shows that the arrangement of the skip bridge, hoist engine, bell operating mechanism, section, etc., is being built along the lines of best American practice.

vide fuel for these furnaces, and the addition later on of open-hearth furnaces and rolling mills to finish all the iron produced in the blast furnaces.

In Fig. 1 is shown the plan of the blast furnace plant. It consists of a blast furnace 85′ 0″ high, having a 14′ 6″ diameter hearth and a 19′ 0″ diameter bosh. The furnaces are arranged in pairs, each pair having a common cast house. The product of the furnace is to be disposed of in ladles; Dewhurst cinder cars being provided for the slag and 75-ton capacity short-pour Pollack ladles for the iron.

Due to the amount of ore available suitable for the making of ferro-manganese, extra large stove capacity is provided, the installation consisting of five 25′ 0″ diameter hot blast stoves, 95′ 0″ high. The stove linings are of the side combustion type laid up with standard 9″ brick. All brick linings for stoves and furnaces are manufactured in India with the exception of the furnace hearth and bosh brick, these being supplied from America.

In addition to a dustcatcher, two centrifugal type dust separators are to be installed, provision being made to later install a dry dust cleaning system.

The skip bridge, hoist engine and arrangement of the bell operating mechanism is of standard design and construction according to the best American practice and is shown in Fig. 2. This drawing also shows a section through the central discharge type of coke bin as well as the arrangement of the coke screens and the coke breeze elevator and bins. For distributing the furnace charge, there is provided a McKee patented revolving stock distributor.

Due to the local topographical conditions the tunnel system for handling the ore from the trestle to the skip cars was used. The ore and limestone bin and storage system consists of a concrete trestle and a tunnel for the scale car runs the entire length of this trestle. The roof of the tunnel consists of a series of unit bin bottoms each provided with a series of continuous segmental type gates arranged for hand-operation from the scale car platform. This arrangement provides a continuous line of gates so that practically all the ore and stone held in storage under the trestle is available at the gates for discharge into the scale cars. The entire stock trestle is double tracked, and on account of the heavy rains at certain seasons, it is covered with a steel roof structure.

The power equipment consists of two 45,000 cubic feet per minute capacity blowers of the Parsons type and the boiler installation consists of 3,500 hp British B. & W. type. The boilers and blowers are to be operated with steam at 200 pounds pressure with 100 degrees superheat. The boilers and blowers are both furnished from England.

For handling the hot metal, two double strand pig casting machines are to be installed, equipped with ladle tilting rigs.

Work on the foundations is progressing and it is expected to put the first furnace in operation during the latter part of 1920.

English Build Large Gas Blowing Engines

Appleby Iron Company Install Eight Horizontal Gas Engines to Drive Generators and Blowers—English Recognize Reliability and Economy of This Type of Engine.

THAT gas engines for driving electric generators and blowers are being given some attention in England, is shown in a recent article published in London "Engineering." The following description of a number of engines being built by Vickers, Ltd., at Barrow-in-Furness for the Appleby Iron Company, Ltd., of Frodingham and Scunthorpe, Eng., is taken from that journal. The first engine, which drives a direct-current generator, is being installed at Frodingham, while the remaining seven engines, five driving Metropolitan-Vickers Electrical Company's three-phase, 50-cycles, 6,600 volts ac generators, and two driving blowing tubs, are for use at Appleby, Lincolnshire. Such an undertaking is interesting evidence of the wide-spread activities in the internal combustion business of the Vickers' concern. Their experience in the manufacture of Diesel engines, including the largest unit in England has stood the firm in good stead with these large gas engines, while their great resources for forging, casting and heavy machining render them peculiarly competent to undertake such work.

The engines, are of the tandem, double-acting four-stroke cycle type. The diameter of the cylinders is 1,100 mm, the stroke being 1,200 mm, separate liners being fitted. The speed of the generating sets is 100 rpm, at which speed an output of 1,200 kw is obtained, but for blowing purposes the speed is reduced to 80 rpm, at which the output is 27,000 cu. ft. of free air per minute delivered against a pressure of 12.5 lbs. per square inch, while arrangements are provided whereby this pressure can be considerably raised in case of need. The blowing cylinder is 95-inch bore, and is clearly shown in Figs. 1 and 2.

The general arrangement of the engine, it will be observed, follows on the more or less accepted lines of the most successful continental types, but in details the Vickers Company, has in collaboration with the purchasers, made a number of improvements to overcome difficulties or trouble experienced by users in England or anticipated by themselves as a result of their internal combustion engine experience. Particular attention has been paid to the intermediate coupling of the piston rod, which in a number of the earlier engines gave considerable trouble. In addition, the design of the exhaust-valve boxes has been thoroughly overhauled. The engines are arranged for working on blast furnace gas, but

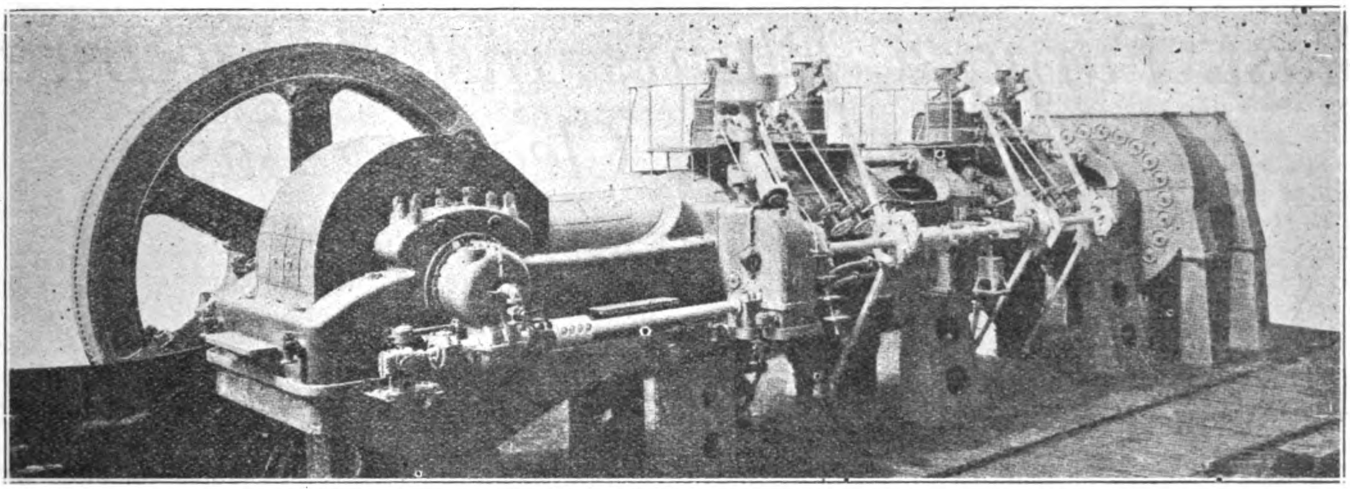


Fig. 1—View of forward end of gas engine and blower for Appleby Iron Company.

by making small adjustments they can be run on other gases, such as producer or coke-oven gas.

The crankshaft, a one-piece forging weighing 20 tons, is provided with separate balance weights, the method of securing which has received special attention. The main bearings are 21 inches diameter, and the four-part brasses are lined with white metal and provided with self-aligning wedge adjustment. The outer bearing is also self-aligning, the brasses being provided with a spherical seat.

Lubrication of the main bearings, crankpin, main crosshead and slipper is carried out by gravity from an overhead tank at a pressure of about 5 pounds per square inch, splash guards being provided round each slipper guide to retain the oil and distribute it over the guide surfaces. All other important working parts are supplied with forced lubrication by adjustable sight-feed mechanical lubricators, which are situated on the intermediate portion of the bedplate.

The piston rods are 10.75 inches diameter, each rod being accurately finished by grinding. They are hollow and convey the cooling water to the pistons. These rods are ground on two centers, so that when the weight of the piston is imposed, the rods are practically free from camber. The piston-rod glands are packed with a number of cast-iron rings, split into three parts and held to the rod by springs which surround them. Three white metal rings of a similar type are fitted at the outer end and the gland, as a whole, is under forced lubrication.

The inlet and exhaust valves are operated by shaped rolling levers driven by eccentrics on the half-speed shaft and eccentric rods, the valves themselves having cast iron heads on steel spindles.

Governing is on the "quantity and quality" system, all important parts of the governor gear being carried on ball bearings, thereby reducing friction to a minimum. The governor fitted is of a powerful type, and has hand adjustment allowing variation in speed either way. Separate hand control for gas and air for each end of both cylinders is provided for use when starting or when the blowing engine is required to run at reduced speed and output.

The ignition is effected by means of two low tension "make-and-break" ignition plugs in each end of each cylinder. The current is supplied from a motor generator delivering current at a voltage of 70 volts, which is distributed by a rotary wiper. This, with its switches and timing adjustment, is fitted at the rear end of the two-to-one shaft. High tension ignition can readily be applied to the engines when such is preferred by the purchasers.

The alternator sets are provided with flywheels of 61.5 tons weight, cast in two parts, which are held together by shrink rings and bolts. The flange of the alternator rotor is bolted direct to the flywheel hub, which gives a very rigid construction and reduces the possibility of oscillation between flywheel and rotor.

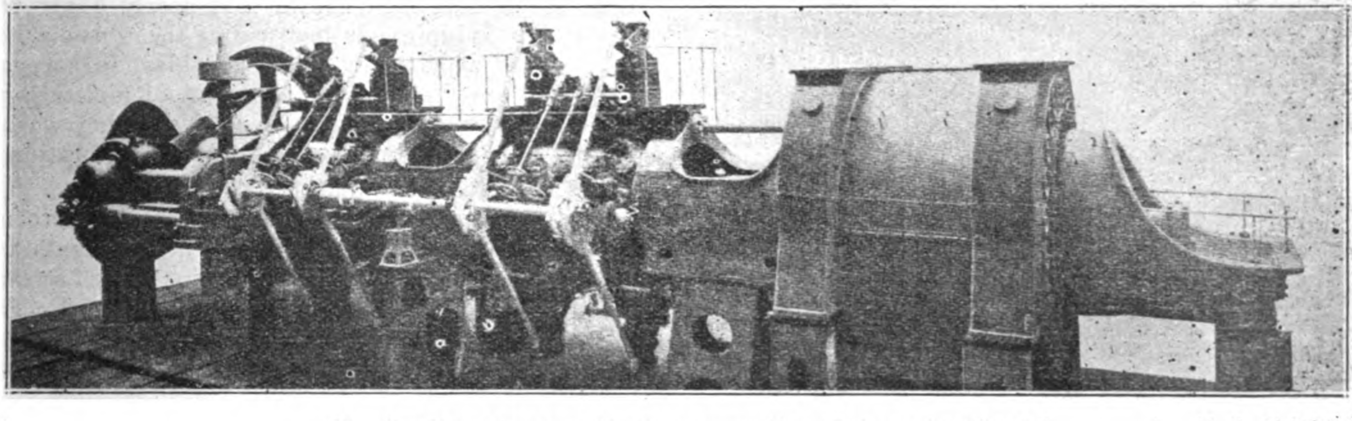


Fig. 2—View of rear end of same engine as shown in Fig. 1.

Blast Furnace Plants Install Electrical Precipitation for Cleaning Gas.

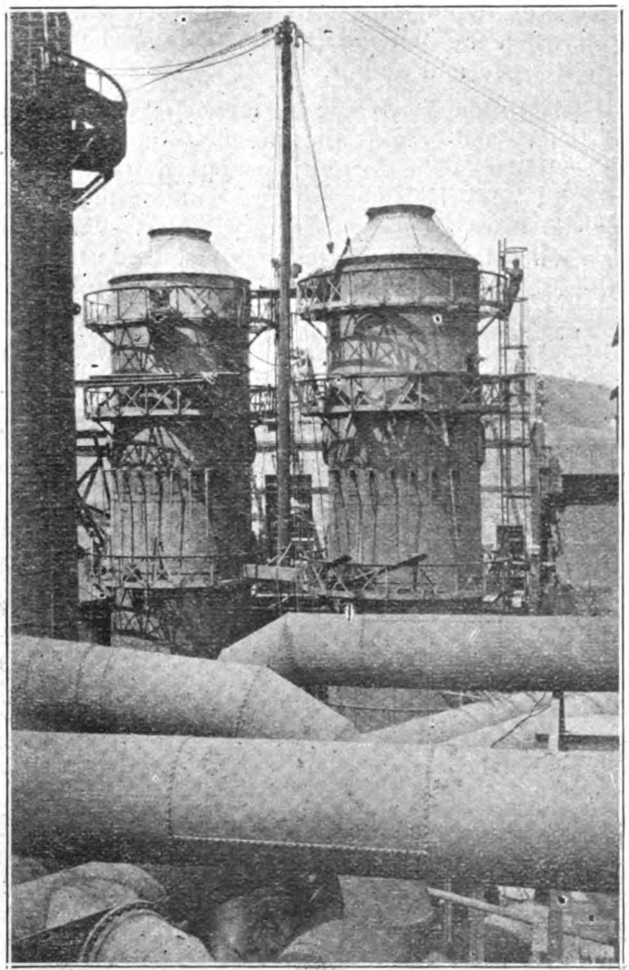
Economies in Furnace Operation Effected by Gas Cleaning—Objections to Wet Cleaning Enumerated and Operation and Advantages of Electrical Precipitation Explained—New Installations.

By N. H. GELLERT,

THERE are three ways in which gas cleaning economies may be effected and may become noticeable to the blast furnace operator.

Clean gas will yield better combustion results and give greater efficiencies per cubic foot burned than will raw gas.

Production of a furnace may often be increased by the operator's ability to blow more air per minute when he can clean his gas effectively. If the velocity of the gas be doubled, it will carry particles four times as large as it originally carried, and unless there is some way to remove the dust before the gas is burned in the hot stoves and boilers, the increase in air blown will increase in a greater proportion the dust content of the gases and the operator may find himself choking up his stoves and boilers with the flue dust. He will, therefore, cut down his blast pressure or else be face to face with the possibility of a complete shutdown for the purpose of cleaning his hot stoves and boilers.



Electrical precipitator ready for piping, Dunbar, Pa.

The economy to be obtained by the absence of the destruction of firebrick in the hot stoves and boilers because of the elimination of dust and fume is a two-fold one; not only is the plant saved the expense of frequent re-bricking and repairs, but the plant is also saved the expense of continual labor in the cleaning of hot stoves and boilers.

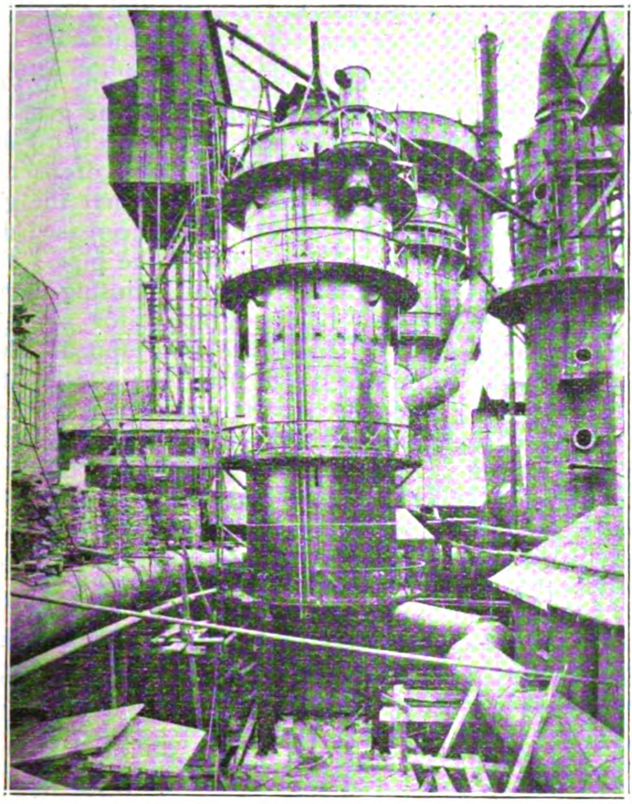
Few blast furnaces in the country are not equipped with some kind of cleaner. A great many of the furnaces, perhaps most of them, have what is commonly known as a dry dust catcher. Various dust catchers have different combinations to cause mechanical impingement, change of direction and decrease of velocity of the gas. The best of them remove about 50 per cent of the total amount of dust and fume carried in the gas. This 50 per cent is the heavy 50 per cent, that portion of the dust which is gritty to the feel and consists of fairly large particles of material. Little, if any, of the fume is removed by the dry dust catchers.

In the United States, the effort to remove this fine fume and dust was for a long time confined to that of wet cleaning. The objections to wet cleaning have been numerous. The main objections to a wet cleaning process are:

The loss in sensible heat due to the reduction of temperature of the gas when using large quantities of water which are necessary in order to get the best results from this method. A table taken from Mr. Diehl's paper before the American Institute of Mining Engineers in 1914 shows that nearly 8 per cent greater Btu value exists because of the sensible heat in the gases when using unwashed blast furnace gas at 400 degrees F. and with 35 grains of moisture per cubic foot, than can be obtained when using washed gas at 70 degrees F., and with moisture saturation at 70 degrees.

The second objection is the pollution of streams. It has been found at several blast furnace plants that fish life eventually is destroyed in those streams where the effluent of the washer is discharged. This has resulted in some places in the enjoining of the furnaces from discharging the effluent into the streams.

The third objection is that wet washers often are not very efficient. The result is, especially where there is much fume in the gas, that the washer does not remove the fume and dust to a sufficiently great degree, and the dampened particles of fume and dust deposit in the stove burners and in the boiler burners and because of hydraulic qualities stay in the burners until they become a hard mass which eventually has to be dug out with chisel and hammer.


The precipitator at Sheridan, Pa.

Another objection is the necessity for large quantities of water. This means a large pumping plant, maintenance and repairs of pumps, a great deal of moving machinery and a large source of supply of water.

To obviate these and other difficulties, the electrical cleaning of gases has been developed. In a simple manner, the action of an electrical cleaner may be described as follows:

The gas is conducted through a vertical pipe. It enters from the bottom of the pipe and issues from the top. An electrode chain or wire is suspended vertically in the exact center of the pipe. It is held taut by a weight at the bottom. This electrode is charged with high tension unidirectional current. It therefore must be suspended on the proper insulators, which are capable of withstanding the potential under which they are impressed. The pipe itself is grounded. When the dirty gas passes through the pipe and comes in contact with the charged electrode, it becomes ionized. As the electrode is negatively charged and has a corona discharge due to the high potential impressed upon it the ionization of the gas is rapid and thorough. The gas molecules carry the charge to the dust particles which for the most part are negatively electrified since the electrons prevail in the gas. Immediately upon being charged, the dust and fume particles are repelled by the electrode and are deposited on the sides of the pipe which interrupt their flight from the chain. The dust particle sticks to the side of the pipe because it is held there fast by the resultant electrostatic force that is acting upon it throughout the entire period of operation. It is as though an arm had extended diagonally from a point on the electrode and pinned the particle of dust to the side of the pipe with a finger and were holding it there without letting go.

In order to secure the unidirectional high tension current that is necessary for precipitation, ordinary line current at about 220 volts, 60 or 25 cycle, is delivered to the switchboard.

There is one circuit from the switchboard through a switch to the synchronous motor. This circuit delivers current to a three-phase motor for the running of a mechanical rectifier to convert the high tension alternating current to unidirectional current. The high tension current is generated through another circuit coming from the switchboard through a circuit-breaker, double-throw switch and five-tap switch to a transformer. At this point, the current is raised from about 220 volts to about 35,000 to 50,000 volts, as needed, and is delivered to the rectifier.

At the rectifier, it is converted to unidirectional current and from that point passes into the precipi-

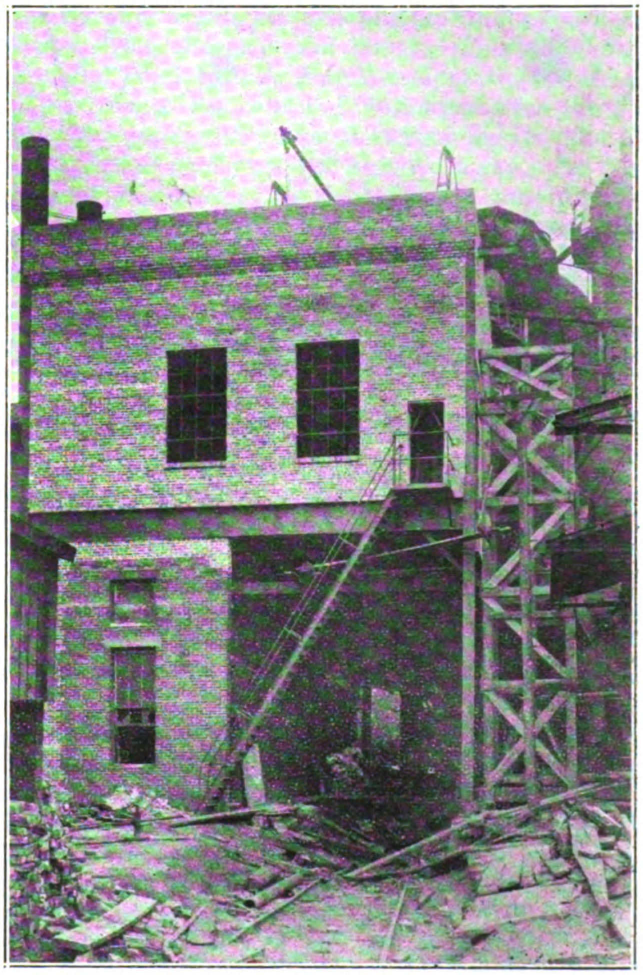
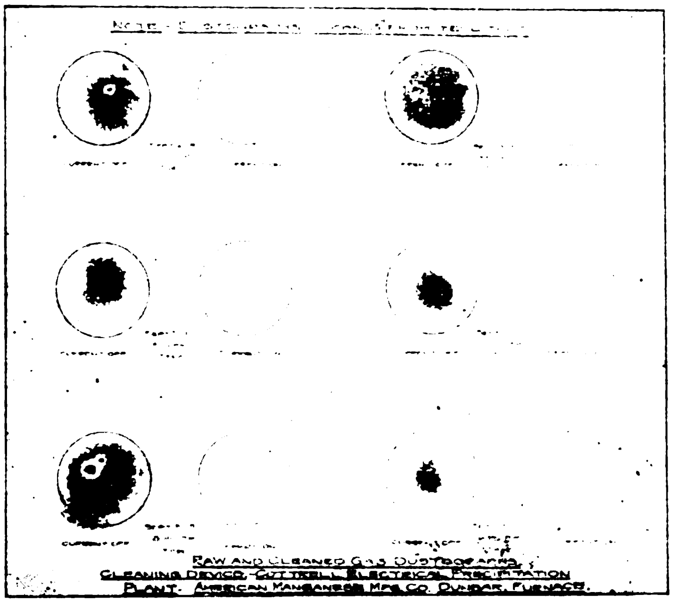


Illustration showing relative position of electrical house and precipitators, Dunbar, Pa.

tator. The use of the five-tap switch and other apparatus in connection with electrical precipitation will be later described.

The plant at Dunbar, like every other precipitation plant at blast furnaces that may be built, consists of two parts, the electrical house and the precipitators proper. It was impossible to place the electrical house on the ground, due to the fact that there was a shortage of room at Dunbar and that part of the electrical house had to be placed over an old blower engine house and another part had to extend over a passageway. For this reason, the house was designed to be 23½ feet above the ground line. Plenty of room was given for the placement of three sets of electrical equipment and the control panels and insulators that were necessary for the work.

Protective screening was used around each electrical set to prevent any chance of accident. The only parts of the electrical apparatus besides the switchboard which extend outside the screening are the motors. All high tension equipment was placed behind the screening. Three complete electrical units are contained in the house.


RAW AND CLEANED GAS DUSTOGRAPHS
CLEANING DEVICE-COTTRELL ELECTRICAL PRECIPITATION
PLANT- AMERICAN MANGANESE MFG. CO. DUNBAR, FURNACE.

Dustographs showing relative dust content in clean and dirty gas.

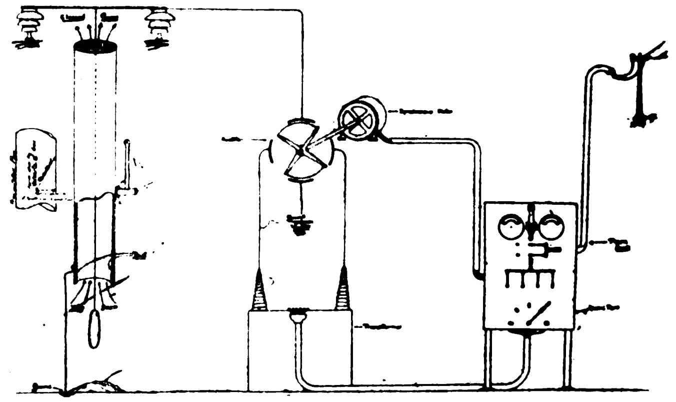
The plant at Sheridan was built a great deal along similar lines. Some difficulty experienced with wet washers led to the installation of the precipitation plant at Sheridan. The plant is about one-half the size of the one put in at Dunbar.

The electrical house, though smaller than the one built at Dunbar is along the same lines, is made of brick, has plenty of light and is big enough to contain two electrical units, although only one has been installed, as it is sufficient for the operation of the precipitator. The plant at Dunbar has been in operation for a little while, while the plant at Sheridan has not yet been operated due to the fact that certain changes being made to the furnace of the plant at Sheridan prevent operating the furnace at all.

The method of operating a precipitation plant is far from being what the average conception of it is. At the present time, the day and night operators at Dunbar are men who before they were taught to run the precipitation plant had never thrown an industrial switch.

After the precipitator is operated from one to four hours, depending on the dust content of the gas, the electrical operation becomes erratic and electrical discharges take place rapidly. The voltage drops and the amperage increases. This indicates that the gap between the pipe and the electrode has decreased due to the deposit of dust on the sides of the pipe. The gas is then cut off by means of a quick closing damper situated in the top of the precipitator and the pipes are rapped. The chains are also rapped. Current, however, is first cut off from the precipitator before anything is done. At the end of the rapping, the precipitator damper is opened again and the current is put on as before. The whole time taken in rapping and shutting down and starting up is between two and three minutes. With a very heavily dust-laden gas, rapping must take place every hour. At Dunbar this has been necessary.

In the short time that the plant at Dunbar has been operating, it has been, of course, difficult to get much data. Visual demonstration, however, was the greatest guide at all times. Dustographs taken by holding a small piece of paper for a stated period of time before the outlet of a small stream of gas impinging on the paper gave a fair indication of what the precipitators did when the current was on and when the current was off. When the current was off, the dust came through the precipitator without being affected at all. The result was that the dust deposited rapidly as gas came through the precipitator without being treated. When the current was put on, the gas impinged against the paper, depositing that dust and fume which got by the cleaning mechanism. Most of the time, this amounted to practically nothing. Dustographs were taken day after day to guide the operators in the results they were getting in the cleaning of the gas. Another visual demonstration that was made was the opening of the doors above the tops of the pipes and allowing the gas to discharge in full force through these doors into the open air with



Diagramatic sketch of electrical precipitation.

the current off so that no electrical cleaning was taking place. A few moments later, the switch was thrown in and current was put on the precipitator and the photograph was taken of the gas being treated by the electrical current.

Examination of the gas as it burned at the stove and boiler burners showed very effectively that when the current was off a white fumy gas issued through the burners into the stoves and boilers and this gas was so thick that when being burned in the stoves the back of the combustion chambers could not be seen by the observer. As soon as the current was put on the precipitators, the clean-up could be immediately noticed; gradually as the observer watched the gas discharge into the inner combustion chamber, it became more and more transparent until the back of the stove combustion chamber could be distinctly seen.

Of course, concrete results followed such treatment. Previously, from four to six men were constantly used at Dunbar in cleaning the stove wells and combustion chambers and boilers of their dust burden. The dust that was discharged into the stoves very often formed into large masses the size of small boulders and could not be removed from the stoves before being broken up with sledge and bar. This of course, was expensive work and very often resulted in the destruction of a large amount of brick work by mechanical hammering. After the precipitators started in operation, the men were taken off the job and for weeks at a time not a single man was used to clean any of the material from the stoves and boilers because of the entire absence of any dust deposits. It was only after difficulties were encountered with the insulators and the plant was shut down for repairs that dust began to collect in the stoves and boilers again, and men had to be used for cleaning. These troubles were purely mechanical and have now been corrected. During the time the plant has operated on ferromanganese gases, perhaps the most difficult of all gases to clean, due to its enormously high temperature and its very heavy fume content, the results have been even more remarkable. Notwithstanding the fact that the tremendously high temperature was causing havoc with the insulators, due to their improper placement and position before the present changes were made, the precipitators continued to clean the gases of their dust and fume to a large extent.

While the primary purpose of a precipitator is not to collect potash, nevertheless, the potash content of the dust when the ores have any appreciable amount of potash, makes this a valuable by-product. Blast furnaces are usually located near where they can readily dispose of their potash to agricultural communities, and this item alone is sufficient to pay the operating expenses of the plant. These expenses are slight when compared to any other system of cleaning. The power consumption is small. From 15 to 20 kva is used at Dunbar to clean from 45,000 to 50,000 cubic feet of gas per minute. One operator is needed during the day and one during the night. Eventually, it is planned, to have an automatic mechanical rapping system, which will eliminate the need for the present operator helper and make it so that the only thing the operator will have to do is to sit in the electrical house and watch his instruments and control everything from the electrical house. This will eliminate manual labor entirely from the operation of the plant. The dust as it is collected is dumped from the bottom of the hopper, and when it is sold for its potash content, is put into cars and shipped away. At Dunbar, the potash content of the dust has run from 7 to 9 per cent on pig iron and it is expected that it will run as high as 20 per cent on ferromanganese.

Remodeling Furnace Plants for Economy

Notes on How Blast Furnace Plants Have Been Re-designed and Rebuilt for More Economical Fuel Consumption and Reduction of Operating Cost.

By F. H. WILLCOX.

WITH the labor and fuel conditions during 1919 presenting increasingly more difficult problems than in previous years, not a few blast furnace operations have reached the point where improvements and betterments or a comprehenhive program of rehabilitation have become imperative. If imperative be too strong a term, it is nevertheless true that the adoption of a plan of betterments that can be carried forward over a period of months, synchronizing both with operations, and, at the end or beginning of the work, with the relining of the furnace stack, can but seldom fail to result in most marked economy and betterment of production.

The main points from which economies may be drawn are in betterments of the fuel consumption of the furnace and the fuel consumption of the furnace power plant; in a reduction on the cost above materials of burden; and in enhanced profits due to increased production of regular grades of iron.

Taking yearly runs of representative furnace groups and comparing furnace operations whose practice represents a fair average of what may be termed progressive ideas in furnace lines, stove equipment, distribution and charging, and furnace management, it is an outstanding fact that there are great possibilities for improvements in coke consumption and higher sustained tonnage. Comparing in a similar way labor and material costs, there is most frequently an appalling difference in the cost of maintenance and upkeep of equipment, in the cost of carrying materials to the furnace and carrying away the products of the furnace.

Labor, fuel and supplies for the furnace power plant are grossly unequal at plants operating under essentially the same ultimate power requirements and having essentially the same quantity of primary fuel as furnace gas.

The quantity of labor, the plant morale, even in districts where two or more plants take their men from an identical source and of even quality, vary beyond the necessities, or in other words, the plant suffering the labor disadvantage is rarely so handicapped that physical betterments in the plant and its auxiliaries cannot wipe out the difficulty.

It is possible to find plants operating on essentially identical furnace cubical capacities, with similarly essentially identical materials of burden and grade of irons produced whose cost per ton varied by as much as $6. On a plant averaging 110,000 tons a year, half of such a saving amounts to $300,000 a year. This would pay 15 per cent interest and depreciation charges on a betterment program involving $300,000, and leave $250,000 a year added earnings.

The ability of any plant to earn money depends on (1) handling the materials of burden and furnace plant supplies economically, conserving labor, switching and power; (2) handling the iron and waste products of the plant in a similar economical manner; (3) production and use of power economically; (4) incorporation of practice abreast of the times in regard to furnace lines, charging, stove equipment and furnace running; and (5) advanced handling of labor.

It is exceptional that study based on previous experience on similar problems cannot evolve a plan of betterment that will benefit the furnace operations involved in part or in whole in the handicap briefly outlined.

Some work of rehabilitation or re-design of existing plants undertaken during 1919, may be of interest to independent furnace operators.

At one plant the furnace had averaged about 165 tons, being hand filled, using non-condensing engines of the vintage of the 70's, with old tubular boilers at low steam pressure. The stove equipment was both inadequate and incapable of withstanding above 10 pounds blast pressure. The plant could run on beehive coke but could not operate to advantage on the denser by-product coke. New stove capacity of 140,000 square feet heating surface was installed. The furnace lines were re-designed, new hearth and bosh installed, cantilever skip and closed top installed, new steel bins with scale car installed, together with ore stocking trestle. A dry cinder pit with steam shovel was installed instead of the old cinder bank where cinder was forked by hand. Water tube boilers were installed together with turbo blower, condenser, generator and service pumps. The remodeled plant will show an increase in tonnage of 50 per cent at a marked decrease in cost per ton, due to savings in operating force charges and a better coke rate.

At a second plant, hand filling was replaced by a new closed top and steel cantilever skip. The old bins were removed and replaced with entirely new bins serving a modern type scale car. The existing skip hoist was remodeled to operate the two balanced skips. Existing three-phase 60 cycle current was utilized for operation of the scale car. The work will not only materially lessen operating charges against production but will relieve a situation where the furnace production was handicapped by disinclination of labor to work steadily and lighten the load on the furnace superintendent.

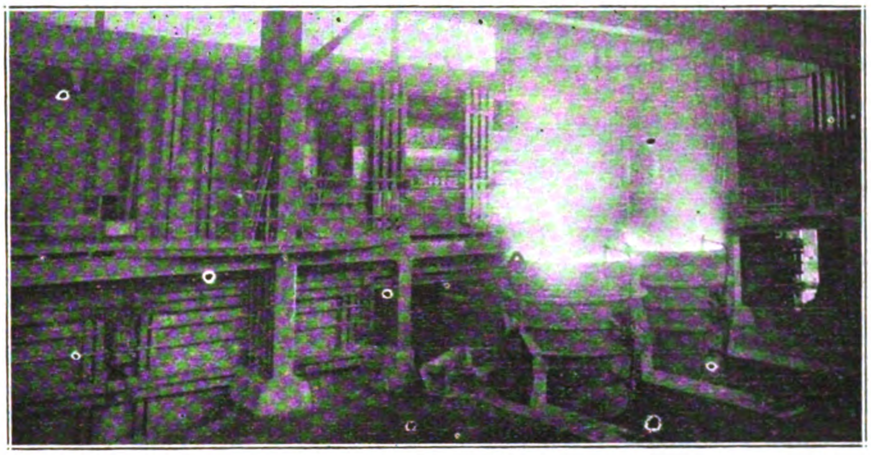
In another instance, factors contributing to reasonable furnace practice were present, but the limitations of coke bins, the capacity of skip incline, the poor top and the furnace lines worked against satisfactory production. The coke bin was re-designed to give greater free flowing capacity, the skip was straightened—there originally being two abrupt changes in angle of ascent of skip—the old offtakes which came off below the bell were removed and a new dome top with four uptakes above the bell placed on the existing shell. A new double bell top was placed. The furnace lines were redesigned and new hearth and bosh steel work placed. While there is practically no change in cubical capacity, the ability to charge regularly, the more satisfactory top, and the better lines should give a marked increase in tonnage at a materially lower coke consumption, together with a freer working furnace.

Another case may be finally cited where the furnace was given an entire new top, an entire new bosh and hearth. The column foundation was renewed and new columns placed. The old columns were entirely removed, the furnace shell being carried at the mantle on heavy beams and at the same time, moved to the true center line beneath skip and the mantle leveled. Many sheets in the shell were renewed. Underground mains were eliminated and new overhead mains installed. The stove linings were removed, the shells cut at the bottom ring, raised 20 feet and new rings inserted, new stove trimmings installed, new linings installed increasing the heating surface by 60 per cent. The furnace lines embody advanced practice and together with the increased heating surface at the stoves and the use of dry cleaned gas from the new whirler installation should give better production with considerable economy.

Space will not permit more than mention of installations of lavatory, locker and wash rooms, service buildings for physicians, police and timekeepers, auditoriums embodying cafeteria service and recreation halls, all of which are singularly pertinent at this time and of proven usefulness in raising the morale of the force. Neither does space permit more than mention of results obtained in boiler and power plant practice betterments, nor mention of investigations of plant operation and equipment that pointed out roads to possible improvements in plant and furnace practice.

The free interchange of views and operation results among blast furnace operators and managers, the consulting services to be found available, and the wide experience of these engineering organizations, and the undoubtedly wide field for improvements should make consideration of a well developed plan for plant betterments a part of the 1920 program most worthy of consideration.

Steel Manufacture Department



OF all the methods of steel manufacture—crucible, Bessemer, duplex, open-hearth and electric—the chief technical progress is to be noted in the two latter methods. The electric furnace is being increasingly used in the manufacture of steel castings. Cost comparisons between open-hearth and electric steel are receiving attention.

The chief problem in the open-hearth process seems to be one of fuel, although refractories are being given considerable study.

In the field of alloy steels development has been proceeding in the endeavor to introduce for general industrial purposes steels containing special elements, hitherto of quite restricted use, such as tantalum, zirconium, cobalt and molybdenum.

An article in this section entitled "Open-Hearth Practice With Large Units," throws some interesting light on the open-hearth process. The article indicates that larger open hearth units may be built. In the same article some interesting illustrations appear, showing the action of a special type of refractory.

Another article in this section presents some valuable information concerning the electric furnace and its power supply. This should be of considerable aid in bringing closer coöperation between the user and manufacturer of electric power to the common good of both.

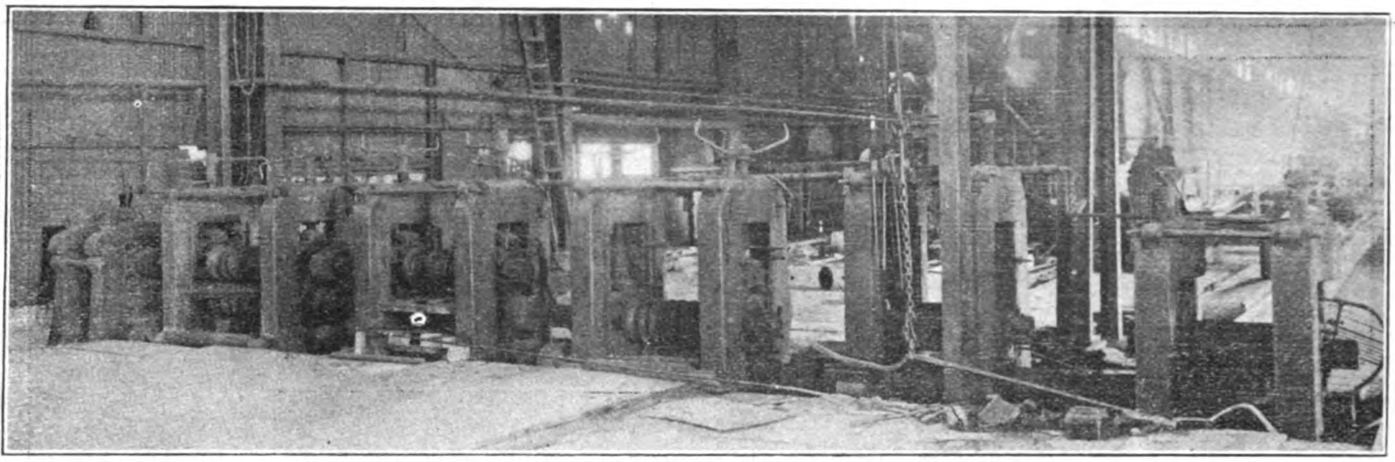


Fig. 1—View of the 10-inch mill.

Braeburn Steel Co., Making and Rolling

New Additions Include Six-ton Electric Annealing Furnace, Wire Sub-station — Data on Steel Proc

By ALFRED

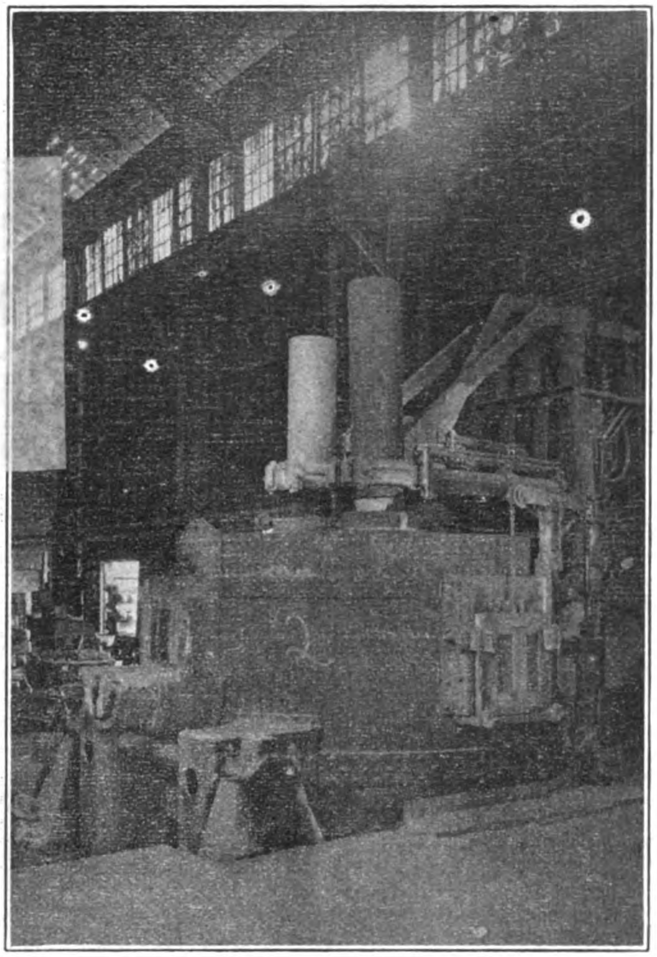


Fig. 2—New 6-ton Heroult furnace.

THE BRAEBURN STEEL COMPANY, located at Braeburn, Pa., manufacturers of high speed, crucible tool steels and electric steels have recently made some notable additions to their plant.

Among the more important additions are: One six-ton Heroult electric furnace, a Baily electric annealing furnace, an entire new wire drawing department, a machine shop, and a new sub-station. The latter is one of the most modern sub-stations in the Pittsburgh district. The well equipped testing and research laboratories are worthy of particular mention, and should go far toward turning out high grade steels. One of the most important products of this concern is high-carbon, high-chrome seamless steel tube stock.

The entire plant embodies a number of buildings, store sheds, warehouses, and an office building. Practically all of the manufacturing processes, however are done in the main mill building and in the new wire drawing department.

Main Building.

The main mill building is 985 feet long and 50 feet wide, of steel construction throughout and commanded by one 5-ton and two 10-ton Shaw cranes. In this building are located the crucible furnaces, the electric furnaces, the 14 inch and 10 inch mills, the pickling bath, the hammers and presses, the heating furnaces, the annealing furnaces and auxiliary equipment. The entire layout of this building is shown in Fig. 6. The two crucible furnaces, one of which is a 24-pot furnace and the other a 36-pot furnace, are fired by producer gas. The two Heroult furnaces are each of 6-ton capacity. Four-ton ladles are used at the crucible furnaces and eight-ton ladles are used to handle the molten metal from the electric furnaces. At present the ladles are cooled with water, although blowers are now being installed which are to provide air for this purpose. It is expected that longer life of the ladle linings will result by using air.

Three coal fired furnaces heat the material to be rolled in the 14 inch steam driven mill. This mill is driven by 750 hp Tod engine, having a maximum rating of 1,000 hp. The Tod engine is located in a power plant which also contains an Ingersoll-Rand air compressor, the air being used in the plant for chipping

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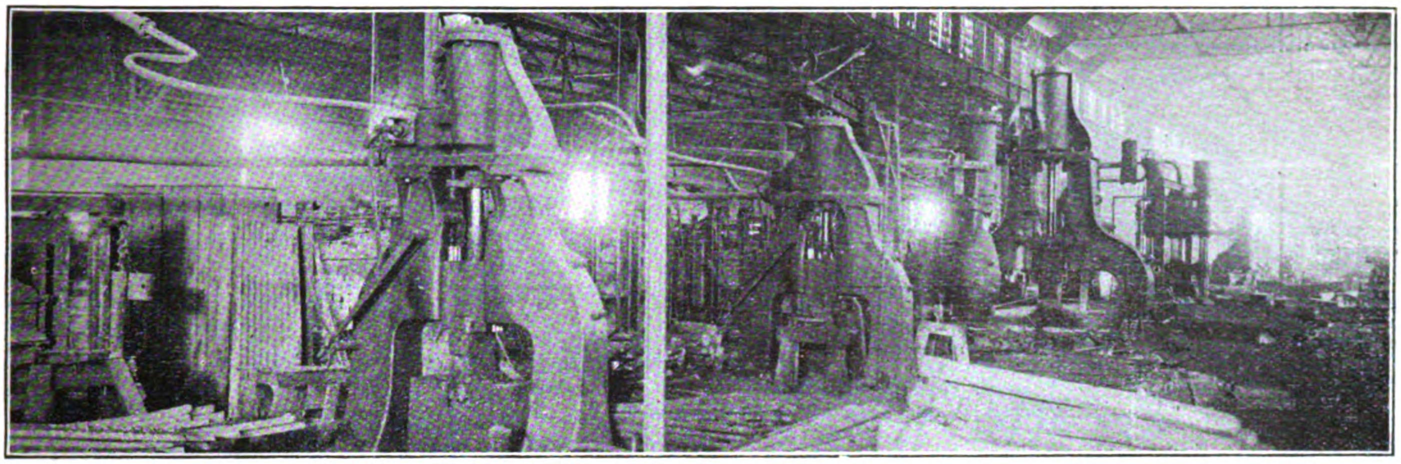

Fig. 3—View of hammers, steam hydraulic press in the distance.

Increases Capacity for High Grade Steels

Heroult Electric Furnace, Baily Mill and Machine Shop and Modern esses and Furnace Power Charts.

M. STAEHLE.

and grinding. A General Electric dc generator set of 1,200 kw capacity develops auxiliary power required in the mill. A Skinner engine connected to a 100 kw Crocker-Wheeler generator is kept as a reserve.

Two coal fired heating furnaces supply the four-stand 10-inch mill, which is driven by a 450 hp Tod steam engine. The mill contains the following steam hammers; one 500-pound, two 2,000-pound, two 1,000-pound and one 6,000-pound, also a 500-ton United Engineering & Foundry Co. steam hydraulic press. Eight coal fired heating furnaces supply the hammers and press. Before being heated in the furnaces the ingots are preheated in gas fired soaking pits.

The present annealing equipment consists of two Tate-Jones car type furnaces 25 feet in length, one Quigley car type furnace 40 feet long and one coal fired furnace. The Braeburn Steel Company is at present installing a Baily electric annealing furnace which it is understood will replace the present annealing furnaces. The Baily furnace is described more in detail in a following portion of this article.

Wire Drawing Mill and Machine Shop.

The new wire drawing department and machine shop are contained in a steel and brick building 240x50 feet. The building is commanded by a 3½-ton Niles crane. Particular attention has been paid to the lighting, heating and ventilation of this modern structure. The air to heat the building is blown over a series of steam coils and distributed through the building by means of 13-inch pipes placed at 20-foot intervals.

The wire drawing department contains a Morgan vertical spindle wire drawing bench electrically driven by a Westinghouse motor; one Morgan horizontal bull frame; one horizontal rod bench; one Schuster wire straightening machine, a Langelier swedging machine, a rotary straightener for putting finish on drill rods, and a buffing stand and inspection bench. The building also contains two gas fired annealing furnaces for annealing the wire between passes.

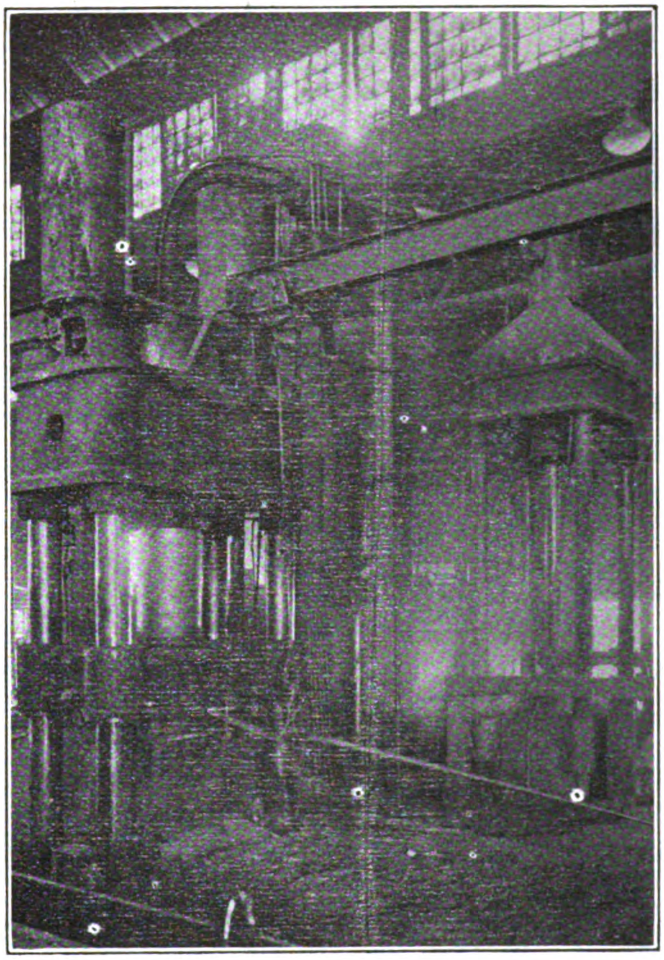

Fig. 4—500-ton steam hydraulic press.

In addition to this the building contains a modern machine shop and a chipping and grinding department.

Pyrometer House.

A pyrometer house is situated near the main building. The purpose of this building is to properly control the operation of the four annealing furnaces pre-

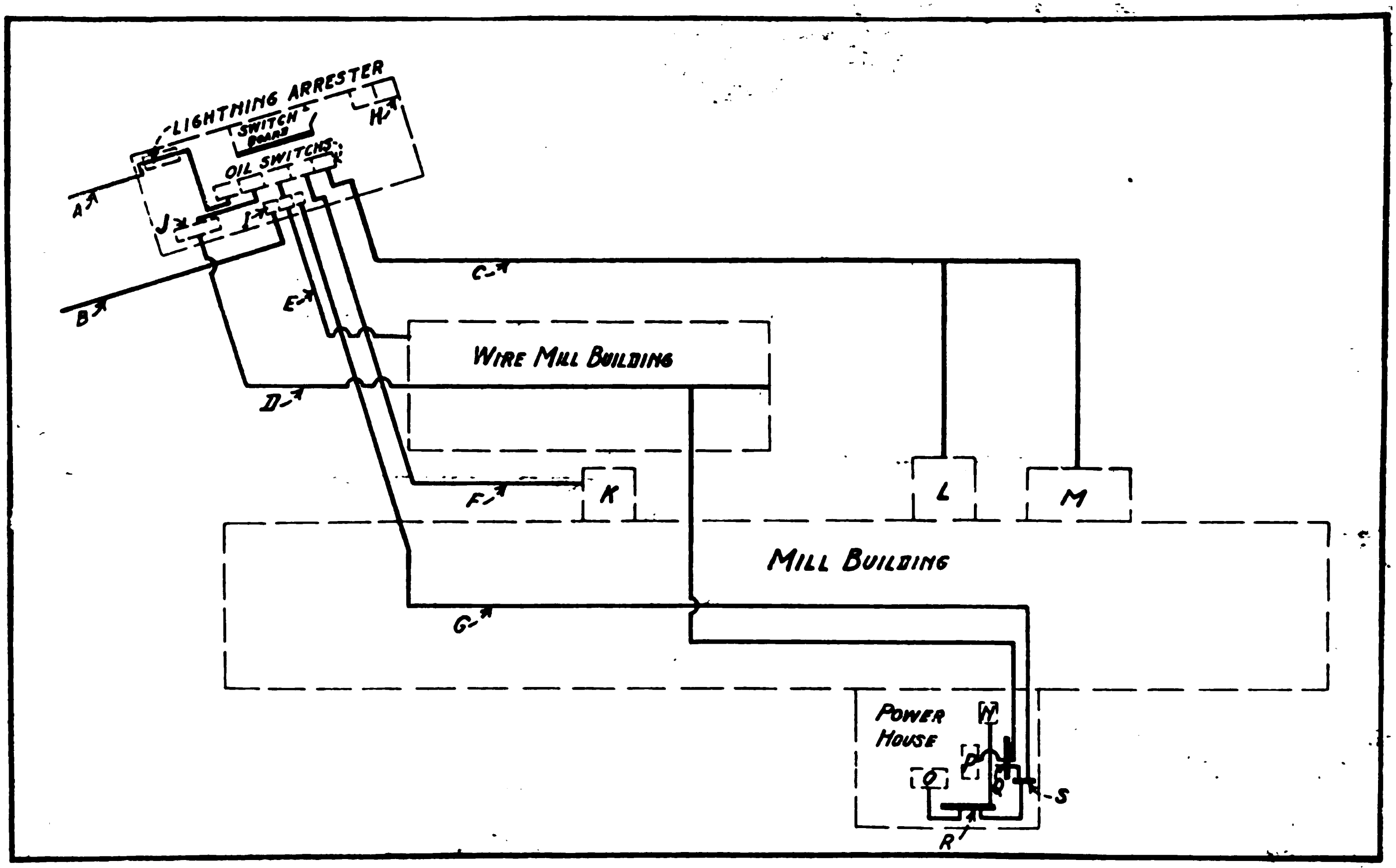

Fig. 5—Key to sketch showing wiring of sub-station and mill.

A—25,000 volt incoming feed line.
B—110-220 volt light line to office.
C—25,000 volt feeder to furnaces.
D—440 volt power line.
E—110-220 volt light line to wire mill.
F—25 000 volt line to electric annealing furnace.
G—110-220 volt lighting line.
H—Potential transformer.
I—Lightning transformer.
J—Power transformer.
K—Transformer housing, electric annealing furnace.
L—Transformer housing E.M.F. No. 2.
M—Transformer housing E.M.F. No. 1.
N—Engine set.
O—Engine set.
Q—Synchronous M.G. set switchboard.
R—Engine set switchboard.
S—Double through switchboard.

viously mentioned. The building contains five Thwing recording pyrometers. These pyrometers record the temperature of 12 thermocouples in the Quigley furnace, six on each of the Tate-Jones furnaces and three on the coal fired furnace. Fig. 8 shows a sample chart taken from the Tate-Jones gas fired furnace while annealing tool steel. Each of the three charts represents one thermocouple. All of the thermocouples on this furnace are on the side of the furnace. The point A, Fig. 8, shows where the heat is started. The line A-B shows the heating of the charge. In order to keep the record of the heat on the same chart the needle is taken from the point B back to C on the chart, and from D for the same reason it is taken to E. Thus the line A B C D E F represents a continuous process. The figures at the bottom represent 100 degrees F. Thus it will be seen that the thermocouple at the extreme left indicated that the charge was started at 4:30 and heated for 14½ hours to point B, the heating was continued for seven hours more and there remained practically constant for 16 hours to point D, then cooled for 17 hours to point F.

Fig. 9 shows the wire annealing process in a coal fired furnace. The wire is cold drawn and the annealing is done between passes. The fluctuation in the curve showing when coal was fired into the furnace. This fluctuation does not appear on the gas fired furnace.

New Sub-Station.

The Braeburn Steel Company have just placed in operation a new and modern 10,000 kva, 25,000 volt sub-station where all purchased power is metered and distributed. The power is purchased from the West Penn Power Company. This sub-station was installed mainly for reducing the power rate inasmuch as the power is purchased on a maximum demand system. It was calculated that by installing all services through one demand meter that the over-all demand would not be great for it would hardly be possible that the maximum load on all services would be attained at the same time. This system also permits the cutting off of any part of the power system without interrupting another. The entire sub-station was designed by the engineering department of the Braeburn Steel Company and also installed by them.

The incoming line is three-phase No. 0 bare wire, protected by a Westinghouse electrolytic type A. K. lighting arrester. The switch board is divided into seven units: No. 1 is the incoming line; No. 2 is a 600

Kva, 25,000—440 volt line for the small meters around the mill; No. 3 is a 150 kva, 25,000—110-220 volt line for lighting purposes; No. 4 is an 800 kva, 25,000 volt line which supplies the new electric annealing furnace described elsewhere in this article. No. 5 is a 3,000 kva, 25.000 volt line which feeds the electric melting furnaces. Units No. 6 and 7 are at present merely for the purpose of allowing for future expansion.

Panel No. 1 contains a graphic watt meter and watt-hour meter of the West Penn Power Company, as well as a similar set of meters which are the property of the Braeburn Steel Company. The two sets of meters thus check against each other. On the swinging bracket to the right of the panel are located power factor and volt meters. On panel No. 2 is located a watt-hour meter, and indicating ammeters. Each oil switch is protected by current transformers operating relays which protect each circuit separately. A sketch of the sub-station and the wiring diagram are clearly shown in Fig. 5.

There are three General Electric 200 kva transformers, 25.000 to 440 volt. The power is distributed by an aerial line to the wire mill where it supplies all motors and then proceeds to the power house where it operates a 150 kva synchronous motor-generator set. Two generators with a combined capacity of 100 kw operate all the old motors in the main mill which are 230 volt dc. This whole system is inter-connected so that any part of the dc load can be run from the engine or from the motor generator set through a double throw switch board. This is so connected that a combined capacity of all units can be obtained if necessary.

There are three systems of lighting, one from the engines, another from the motor generator set, and still a third from one of the lighting transformers in the main sub-station. These are interconnected through double throw switches so that any system can be used and all can be controlled in the engine room. Incandescent lamps are used throughout so that either dc or ac current can be used. There are three 50 kva lighting transformers, one for the small electric furnaces in the metallurgical and chemical laboratories and the office lighting, one for lighting the wire mill building, and the other for lighting the main mill building.

The electric annealing furnace takes its power from panel No. 4 from the main sub-station and is Scott con-

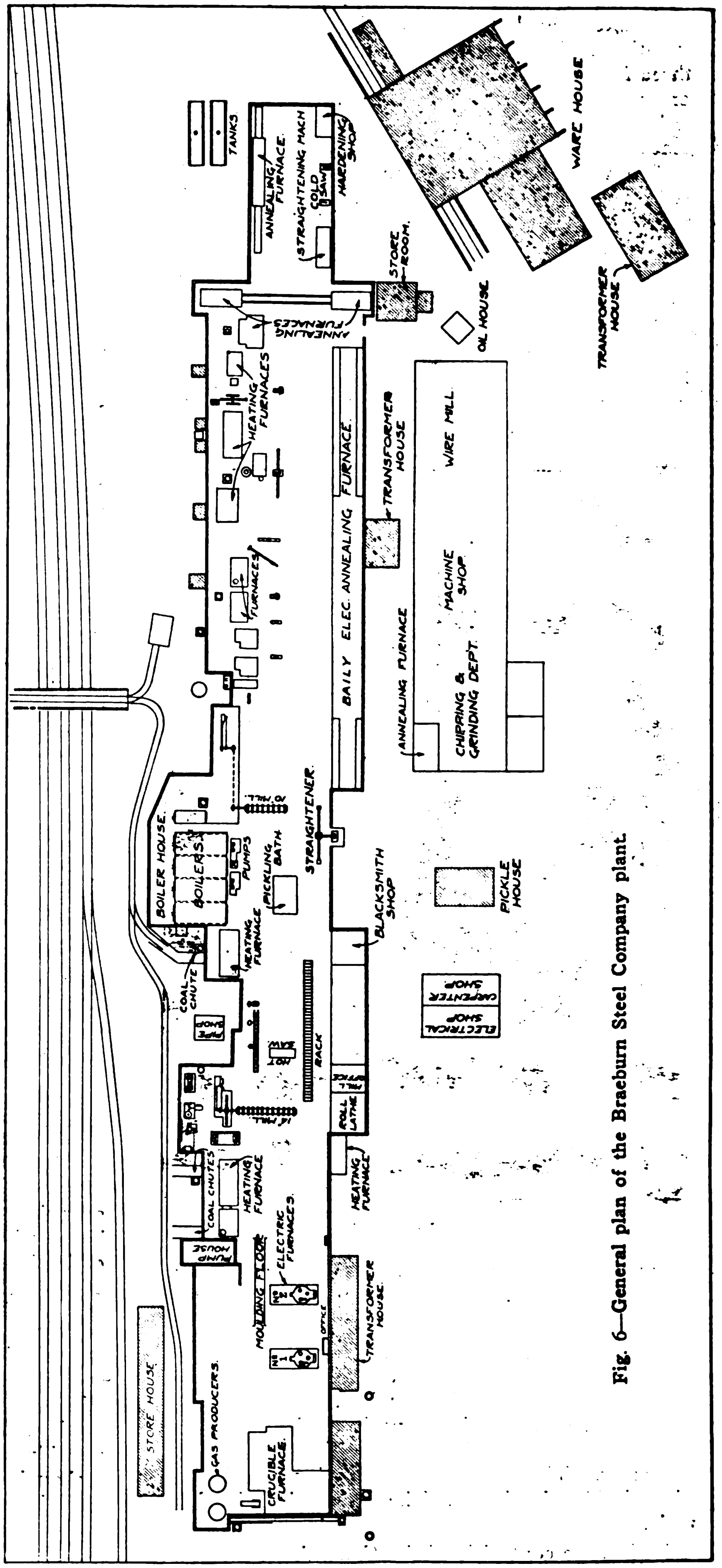

Fig. 6—General plan of the Braeburn Steel Company plant.

nected with two single phase 400 kva transformers to a balanced load on a three-phase system. This installation has its own sub-station with a feed to it of three No. 4 bare wires coming direct from the panel of the main sub-station. The electric annealing furnace has a variable voltage from 275 to 575 volts for regulating the heat. This is controlled by oil switches. A 25,000 volt line is run from panel No. 5 to the electric furnace transformer house. Each sub-station is protected by a Burke horn gap switch.

Electric Furnaces.

Two electric furnaces are used in this plant for making electric steel, both of which are of the Heroult type and are each of six tons capacity. Furnace No. 2 has recently been installed, furnace No. 1 having been in operation for some time. There is little difference in the two furnaces with the exception of the fact that the older furnace tilts on a rocker whereas the new furnace tilts on a trunnion. The power for these furnaces is purchased and is received at 25,000 volts, 60 cycle, 3 phase, and transformed to 110-100 volts. Both furnaces are equipped with General Electric transformers. Furnace No. 1 is equipped with three single phase transformers, each 400 kw capacity. Furnace No. 2 is equipped with one three-phase 1,500 kw capacity transformer. The average consumption per furnace per heat is 4,200 kw hours. The average heat is 13,500 pounds.

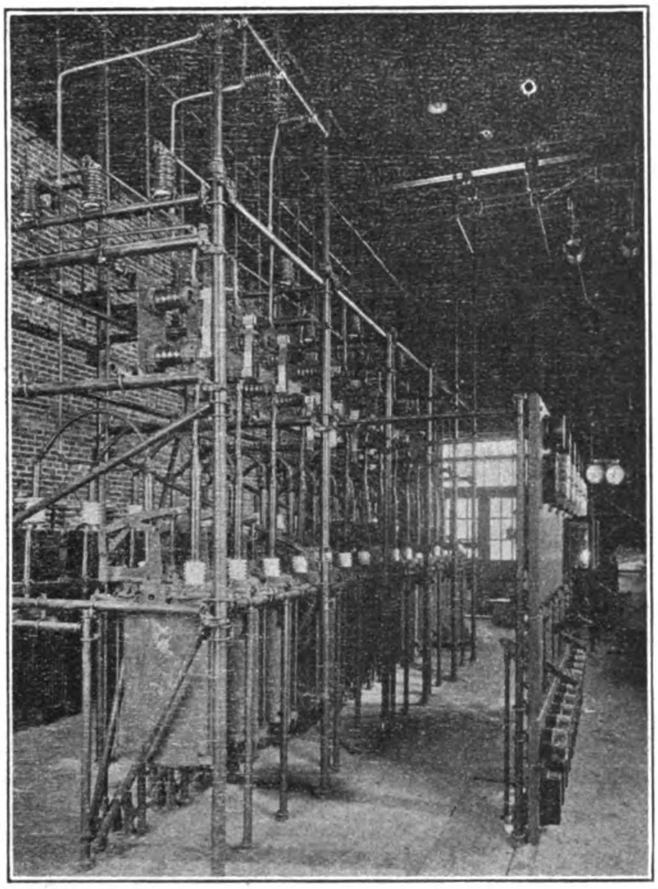

Fig. 7—Interior of new sub-station.

The furnace control is of the General Electric type throughout. An auxiliary regulator panel is provided. This panel contains push button stations for hand control, and a 4-pole double throw switch for changing from hand to automatic control and vice versa. The lever switch is drawn to the right for hand control and to the left for automatic control. When thrown to hand control the contactors are controlled by push button stations and the shunt relays are thrown out of circuit so that the electrodes can be moved regardless of the condition of the ac circuit.

Both furnaces are basic. The steel shell is ¾ inch in thickness. The refractory lining is 18 inches in thickness throughout. Silica brick is used on the roof, magnesite below the slag line and Metalkase above the slag line. Seventeen-inch amorphous carbon electrodes are used.

Electric Annealing Furnace.

A Baily electric annealing furnace has been installed, although it is not in operation as yet. This furnace is a 600 kw, recuperative type capable of treating 75 tons of material in 24 hours. The furnace equipment is approximately 220 feet long, with a 30-foot heating chamber in the center, and two recuperative chambers on each side. The material to be treated is loaded upon cars each 15 feet long. Two tracks run through the entire furnace and are long enough to accommodate 24 cars.

The material is stacked upon the cars and is drawn into the furnace by an automatic motor-controlled pusher mechanism. As two cold cars of material enter the furnace at opposite ends, two cars of treated material are at the same time ejected from the furnace in similar fashion.

As the cold car enters the recuperative chamber, it takes on heat from the car passing out on the opposite track, thus it is brought very slowly up to the maximum heating temperature. The car takes 40 hours to pass through the heated section, and then passes out through the second recuperative chamber, at the same time giving off its heat to the colder car that is passing on the opposite track.

It takes 72 hours for a car to make a complete circuit through the furnace. The operation of the furnace is entirely automatic and the closest possible control over temperature is made possible by this type of electrical equipment.

Heat is furnished in the main chamber by means of two carborundum troughs which are packed with granular carbon. When the current is turned on these become incandescent and radiate heat evenly over the entire hearth area.

Electric Steel Process.

High carbon chrome steel is usually made in the electric furnaces and is later made into annealed seamless tube stock. The average charge consists of 3,000 pounds of heavy chrome scrap, 2,000 pounds straight carbon heavy scrap, 1,500 to 2,000 pounds punchings and the balance of miscellaneous straight carbon light scrap. Burned lime is used for fluxing material, 300-350 pounds being used per heat. About one-half of the lime is thrown in shortly after the power is turned on and the remainder when the deoxi-

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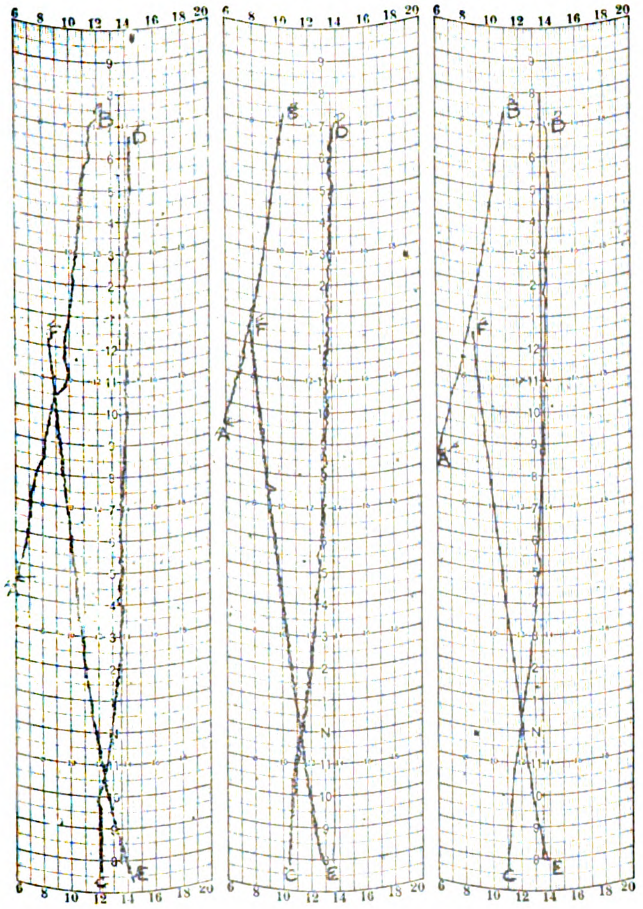

Fig. 8—Electric pyrometer charts showing annealing of crucible tool steel in gas fired furnace.

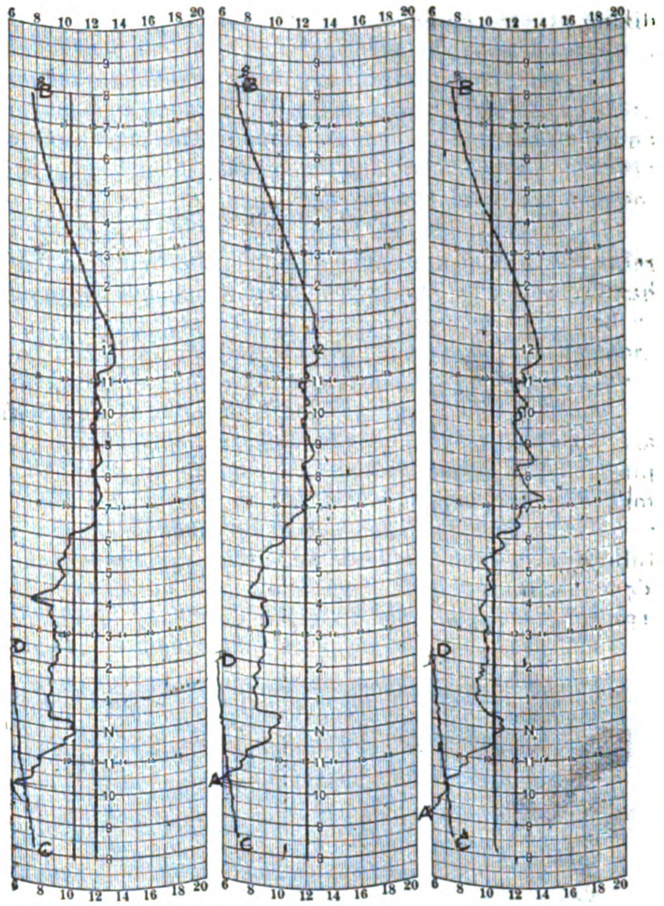

Fig. 9—Electric pyrometer charts showing annealing of high carbon tool steel in coal fired furnace.

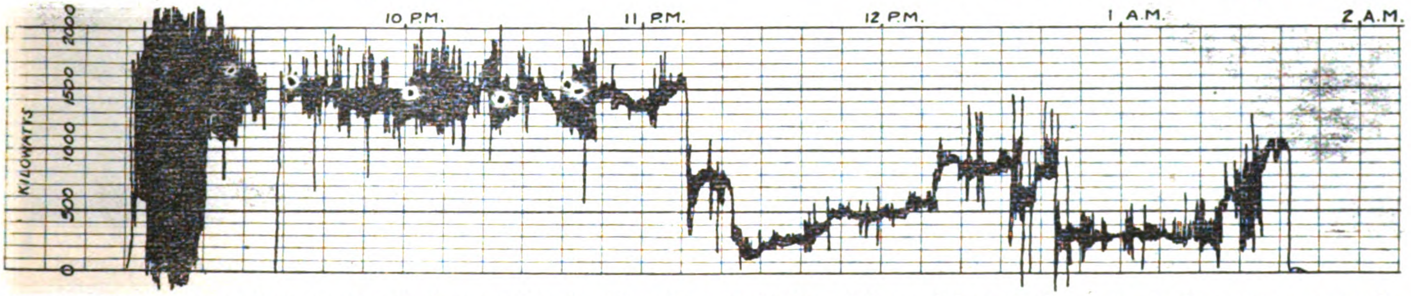

Fig. 10—Power chart taken on electric furnace No. 2. The chart reads from left to right and the amount of power consumption is indicated at the left.

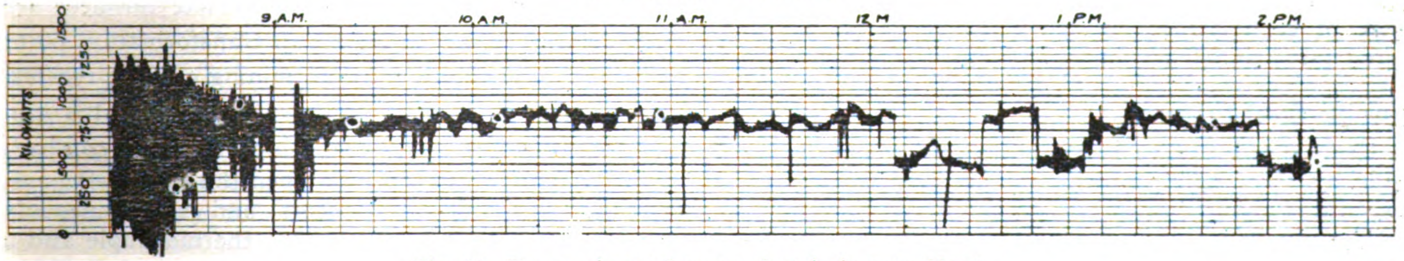

Fig. 11—Power chart taken on electric furnace No. 1.

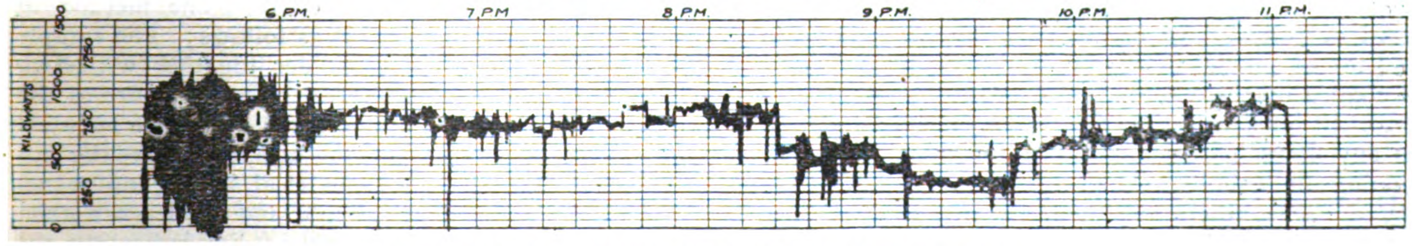

Fig. 12—Power chart taken on electric furnace No. 1.

dizing process commences. A suitable amount of coke is charged with the scrap.

At least two preliminary tests are taken on each heat. The heat is held in the ladle about five minutes and then top cast. The majority of the ingots poured are 7x7 inches, 9x9 inches or 13x13 inches. Split moulds are used exclusively.

The ingots poured from the electric furnace are reheated in coal fired furnaces prior to being rolled or hammered. The 7x7 inch ingots, which are eventually to be rolled into smaller sizes, are cogged on the 14 inch mill. The balance are cogged on the 3-ton hammer. After the preliminary hammering or rolling they are cut into billets and pickled to remove scale. They are then inspected and the defects removed by chipping. After being rolled into rounds in the 14-inch mill they are cropped and cut to lengths on the hot saw. The rounds which are to be made into seamless tubing are then pickled and sent to the grinding department for final inspection and removal of all remaining seams. Six to eight days are required to anneal a charge of from 30 to 40 tons. After removal from the annealing boxes a careful examination is made of each round. A disc cut from each bar is tested for Brinnell hardness and grain structure.

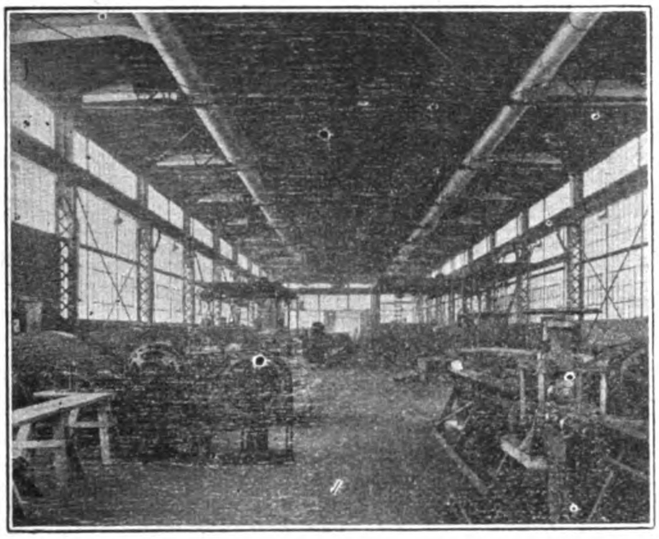

Fig. 13—**Interior of new wire drawing department.**

Crucible Steel Process.

High speed and various grades of tool steels are made by the crucible process. This type of product constitutes about 25 per cent of the firm's output.

The crucible charge is made up of muck bar, the necessary ferro-alloys and picked scrap. The crucible ingots which are poured in split moulds are later hammered or rolled. All crucible ingots are cogged on the 3-ton or smaller hammers. Low carbon tool steels are cogged on the 500-ton press. All high speed steel is worked on hammers. After being formed into billets any flaws in the material are removed by either chipping or grinding, the high speed steels being ground. The billets are then reheated in coal fired furnaces prior to being rolled into finished shapes on the 10-inch mill, or prior to being finished on the small hammers. The shapes which are to be made into tool steel are annealed and the wire coils are sent to the wire mill for cold working. A considerable quantity of high speed steel is made into bits. This material after being cut to length is sent to the hardening shop and later put through tumbling barrels. The bulk of the tool steels is shipped out in the annealed condition.

Metallurgical Department.

Ample facilities for the proper testing and inspection of the steel are provided by well equipped chemical, physical and research laboratories. The metallurgical department has supervision over these laboratories as well as over the inspection department.

The physical testing laboratory is equipped with a 100,000-pound Olsen testing machine, an American model Brinnell hardness testing machine, a torsion testing machine, as well as polishing and buffing machines.

The research department is amply equipped to conduct experiments. Two Hoskins electric muffle furnaces and three Tate-Jones gas crucible furnaces are provided. A Leeds & Northrup transformation point apparatus is available for determining critical, recalescence and decalescence points. This apparatus employs a difference couple and a high sensitivity reflecting galvanometer to indicate when the sample is passing the transformation points and simultaneously measures the temperature with a thermocouple and a potentiometer. The apparatus produces a graphical chart of the transformation curve. The method of operation of this apparatus is as follows: The sample is placed in a cylindrical holder together with two thermocouples. One measures the temperature of the sample, the other, the temperature difference between the sample under test and the sample holder, the latter being composed of a material having no transformation points. The sample and holder are then placed in a small electric furnace. For indicating the changes in the electromotive force due to the transient

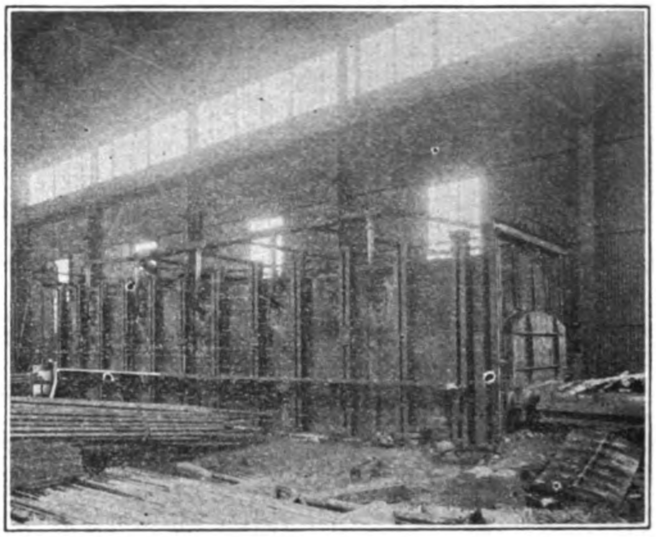

Fig. 14—**Annealing furnace.**

differences in temperature of the sample and sample holder, a sensitive reflecting galvanometer is employed. The other thermocouple is connected with a potentiometer to show when a balance is obtained, that is, when no current is flowing.

A transformation point indicator is placed in line with the reflecting galvanometers. This indicator carries a drum. The paper upon which the chart is to be made is mounted upon this drum, which also carries the potentiometer slide wire. Bearing upon this drum is a pen. As the drum is revolved by means of a knurled wheel by the operator, the drum automatically records the temperature of the sample, upon the paper. The operator turns this wheel so as to always keep the potentiometer galvanometer at the "no deflection" point. That is, as the sample heats up he must keep turning this wheel to keep the potentiometer galvanometer at zero, and vice versa when cooling. Simultaneously, a movable target is brought in line (by means of another knurled wheel) with the beam of light reflected from the difference galvanometer. This adjustment moves the pen from right to left and records the temperature difference between the sample and sample holder. The ordinates of the resultant transformation curve will show the temperature of the sample and the abscissae will show the temperature difference between the sample and the non-recalescing body. The curve then shows at what temperature the steel passed through the critical, the recalescence and the decalescence points.

A Scimatco optical bench is provided for the observation and photography of the micro-structure of the steels.

A well equipped chemical laboratory is provided for the analyses of all kinds of alloy steels. A Hoskins muffle furnace is used for ignition and the annealing of hard specimens submitted for analysis. The balance room is especially located with the idea of avoiding air currents and sudden changes of temperature.

Special apparatus for determining the sulphur in steels containing tungsten is provided. The process is as follows: Hydrogen is passed over the sample drillings which are heated in a combustion furnace. The hydrogen reacts with the sulphur of the steel forming H_2S gas which is absorbed in a strong ammoniacal solution of cadmium chloride. The resulting yellow precipitate is then treated with potassium iodate as in the ordinary evolution method for sulphur.

The inspection apparatus in the main shop consists of two saws. The disks, cut from the rounds to be inspected are tested for Brinell hardness and for grain structure. The research, chemical and physical testing laboratories as described are in the same building as the main offices, shown at the extreme right of the plant layout.

Electric Furnace Developments During 1919

Smaller Size Furnaces Favored—A Few New Furnace Manufacturers Enter Field—Electric Duplexing Gains—Electric Furnace Association Formed—Experiments in Iron Foundries.

THE leadership attained in the manufacture of electric steel, in this country a number of years ago has been increasing satisfactorily during the past year. Available information indicates that this prestige will probably continue. At the conclusion of the war, the United States was in far better condition than its allies to carry on industrially. This advantage applied particularly to the steel industry. New South American, Far Eastern and other trade territory had been at least partially developed. The country was in position to handle business already developed, as well as to go after prospective business to the best advantage. This unique situation, largely the result of the war, has created a demand for manufactured products from which the makers of electric furnaces and the users of electric steels have been favored with a fair share of the opportunities.

At the expiration of the year just passed, there were some 20 different concerns manufacturing or selling various makes of electric furnaces in the American markets. This is an increase of perhaps five over that of the year previous. The new concerns, however, include those turning out furnaces for non-ferrous metals, as well as for steel making. While authentic data is not available regarding the actual number of furnaces sold or contracted for during the year, it is safe to assume that approximately 45 electric steel making furnaces were either placed in operation or contracted for in the United States and Canada. This is a marked increase when the limited period of development of the electric furnace is compared with the time other common processes have been in use.

Many customers, who have heretofore been content with the use of converter or open hearth steel, are more frequently specifying electric steel for their more important work. It has been observed that the firms in position to advertise electric furnace steel and to fill their orders for this product, are the ones which are operating to full capacity at the present time. It is only within the past year that this condition has been realized. A glance through the advertising pages of current steel magazines furnishes ample proof of the manufacturer's appreciation of the popularity of electric steel.

The tendency has continued during the past 12 months to further increase the manufacture and sale of polyphase furnaces of the arc type. The use of single phase or induction furnaces, especially in larger sizes, has been practically abandoned by steel makers. Opposition to single phase and induction type furnaces is due to their unfavorable operating efficiencies and to the opposition of central station companies. The latter opposition is due, of course, to the unsatisfactory load condition which they produce on power circuits.

It is noteworthy that the demand for furnaces of capacities greater than 15 tons per heat is rather limited. It is, of course, true that electric furnaces will turn out more steel per day than open hearth furnaces several times their tonnage rating. The small sizes, however, seem to be in more general favor and better able to show marked economies. Furthermore, many purchasers of electric furnace equipment prefer to make their initial investment in smaller sizes of electric furnaces, so as to try them out before tearing away their fuel burning furnaces and substituting electric. For making thin section or small light castings, the superiority of the electric furnace has long been recognized. It is not thought, however, that the electric furnace is by any means limited to small or special classes of work. Wherever electric power is available from large hydro-electric or steam-generating stations, the economic advantage of the electric furnace will gradually become more apparent. It seems to be generally recognized that the future holds wonderful possibilities for the more extended use of larger furnaces.

In comparison with the crucible furnace, the converter and the small open hearth furnace, many users concede the cost advantage to be in favor of the electric furnace. Some manufacturers of tool and special high-speed steels contend, however, that the product of the crucible process cannot be equalled by the electric furnace. Whereas this contention may possibly be open to question, the fact, that many other crucible plants are now using electric furnaces goes to show that this opposition is gradually disappearing.

During the war a great impetus was given the electric furnace for steel manufacture. After the armistice had been signed there seemed to be some question as to whether the use of the electric furnace would be extended as rapidly as indicated during the period of the war. It seems, however, that the electric furnace is easily holding its own and that the future holds great possibilities for electric steel.

Considerable discussion has taken place during the year regarding more extended, new and heretofore unthought of uses of the electric furnace. The application of the duplexing process, whereby steel is preheated in the converter or open hearth furnace, and later refined and superheated in the electric furnace, has been further developed. In fact several new installations of this sort have been made during the year. The quality of the product handled in this manner is said to show marked advantages.

A number of experiments have been made in the use of the electric furnace in gray iron and malleable foundries. Where especially sound and fine cast or malleable irons have been needed for pouring light or thin section castings, this application of the electric furnace has exceeded expectations. The furnaces have either been loaded with cold charges or with preheated metal from the cupola. It is well known that by ordinary means of production considerable phosphorus is required for making gray iron or malleable castings, in order to secure the proper degree of fluidity. As any desired superheat may be obtained in the electric furnace, iron much lower in phosphorus content may be used and greater strength and toughness in the castings may be attained. Without doubt the possibilities of this new and promising application of the electric furnace will be widely developed during the current year.

A number of minor changes have recently been made in the mechanical and electrical designs of electric furnaces, in order to improve and simplify their operation. Less complicated mechanisms for tilting and better facilities for changing roofs, relining, charging, slagging, pouring and speeding up the furnaces have been adopted. Furnace electrodes are said to be of better quality than were formerly available, but little improvement has been noted in the refractories used for furnace linings.

Most of the furnaces are being installed for acid operation. This is due to the vast quantity of cheap high grade scrap available, which requires little or no refining and which makes it possible to produce excellent steel at minimum cost. Some furnaces are made for the production of acid steel only, whereas others are designed for either acid or basic operation.

For the production of alloy steels, the electric furnace possesses a marked feature of superiority over the open hearth, in that the losses of expensive alloy ingredients, which often run from 35 to 40 per cent in the open hearth furnace, are reduced to practically nothing in the electric furnace.

Much desirable data are yet to be gained and collected on physical tests of electric steels, compared with those produced by other means. Little information of this sort has been published and a large field of activity is therefore afforded the investigator.

Some valuable information of this sort has been collected by the Electric Furnace Association. The association was formed during the past year. Its membership is open to makers of electric furnaces and their auxiliary equipment, as well as to those directly interested in the products of the electric furnace. Although it is only a new organization, much good has already been accomplished and its growth will be watched with much interest. Results of tests tabulated and published in a small booklet by the association are naturally in meagre form as yet, but they serve to indicate that physical properties of electric steel are universally superior to those obtained from either converter or open hearth steels.

According to the best information available, approximately 850 electric furnaces for the production of steel were in use throughout the world at the end of the year, approximately 375 of which were located in the United States and Canada.

Among the reasons for the rapid growth of the electric steel industry, it may be said that a higher quality of product is now required than would serve the purpose a few years ago. The war created a market for steel, the rigid specifications of which could in many instances be met only by the use of the electric furnace. Furthermore, the electric furnace affords a more scientific and better way of producing high quality steels.

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1919 Open Hearth Technical Developments

Important Advances Occur in Solution of Fuel Problems, in Furnace Construction and in Theoretical Principles of Steel Making.

By FRED CRABTREE

THE year 1919 saw practically no notable new developments in either open hearth furnace construction or in open hearth practice. During the first part of the year there was the relaxation from the intense strain of 1918, and the profound uncertainty as to what was going to occur. Contracts were being cancelled, labor was restless, transportation was deficient, and all of Europe was on the verge of bankruptcy. Retrenchment, rather than pioneering in any new line, seemed to be the sound policy. Then a change came rather quickly, in some respects at least. There developed a large demand for many steel products, and the industry seemed to be entering on a period of unsurpassed prosperity; but labor troubles intervened, disarranging all plans and disappointing ardent hopes. Every effort had to be concentrated on keeping the wheels of industry turning in the established way, and no consideration could be given to any innovations that were likely to in any way interfere with production. Such conditions are extremely unfavorable to the development of any radical changes or improvements.

The author of this article indicates that some interesting investigations regarding the open hearth process, have been made in this country during the year which may be of considerable value when the results of these investigations are more generally known. Much attention has been given the publication of a considerable amount of data on this subject in England and it is to be hoped that the same publicity will be given any investigations which have been conducted in this country.

However, this does not necessarily mean that open hearth and construction practice have been at a standstill, and have made no progress. It is probable that never before were the plants in as good physical condition as now. Advantage has been taken of the opportunity to rebuild or to repair, and to put in improved appliances that have already had some successful demonstrations—for example, water cooled equipment of various kinds, and metal encased magnesite brick.

It is emphatically stated by several users that the Washington magnesite has proved to be just as good as the Austrian material, and has attained a permanent place in the market, and apparently the treated dolomite products are still used extensively for patchwork.

The fuel problem is as ever, a very live one, in spite of the fact that many of the large companies have built by-product coking plants and have thereby secured a supply of gas and tar. Good results have been obtained, it is said, by using a mixture of natural gas and by-product oven gas. But for the companies which do not have the by-product gas there is still the choice between producer gas, powdered coal and oil. Unfortunately much of the coal mined has had unusually high sulphur content, causing much trouble with the producer gas. The oil market seems to be very uncertain; during the same week it is reported on the one hand that oil companies are profiteering outrageously, and on the other hand that they are offering contracts at very low prices. So some large companies are again carefully considering the use of powdered coal.

On the technical side, it is admitted that the demand for high grade, well made steel, so emphasized during the war, still continues. It is now known that "cleaner" steel is desirable and obtainable, and there have been much study and effort devoted to its production. In some lines the specifications, imposed by the purchasers are becoming more exacting than ever before, and tax the highest skill of the operator. There is a growing demand for special steels, each suited to a particular use.

English journals refer to the practice of partially refining the pig iron in a mixer, mainly for the removal of excess of silicon; but this idea has not appealed to American steel makers. It is said that the United States Steel Corporation made an extended test, lasting several weeks, of something along this line, but found it had no advantage over the duplex process. In these tests not only silicon, but manganese and carbon were reduced in the preliminary furnace, thus making it approach the duplex process.

Perhaps the most development has been the recognition of the fact that there is so much to learn about the principles involved in furnace construction and in the theoretical principles involved in the operations of making steel; and the indications of an attempt to coördinate the studies of these important matters. English investigators, during the past two or three years, have published elaborate studies of the acid open hearth process. In this country much work has been devoted to the study of both the acid and basic processes, but not much of the information has as yet been published. However, knowledge so gained is certain to spread, and there can be no doubt that the open hearth industry as a whole will be materially advanced theoretically and practically by what has been done so quietly during the past year.

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The Electric Furnace and its Power Supply

Useful Data on Power Consumption in Electric Furnace Operation Presented—Greater Co-operation Between Furnace User and Power Company Urged — Power Rate Curves.

By E. A. WILCOX,
Pittsburgh Electric Furnace Corporation.

IN a general way it may be said that the interests of the electric furnace user and of the central station company are mutual. Each enjoys or anticipates a profit from the operation of a furnace—the former from the steel output—the latter from the energy input. Close coöperation between these two interests cannot but result in advantage to both.

Coöperation Essential.

Irrespective of this self-evident relationship, that should obtain between the power company and the user of electric furnace equipment, a reversed condition is often found to exist, where the parties concerned give little heed to one another's viewpoint. This plight is frequently the result of misunderstanding. The training of the central station man is quite unlike that experienced by the steel maker. Technically, they speak different languages. The former may not understand the importance of a quick "melt down" of the charge any more than the latter may comprehend the significance of good "load factor" or well balanced circuits. The points of difference are often of the simplest nature, but being foreign to experience, frequently give ground for unjust suspicion, which can be obviated only by getting together and going over the difficulties.

Electric Furnace Rates.

Some of the points over which discussion is bound to arise and on account of which misapprehensions may come about, are here considered from an unbiased viewpoint. The first clash of opinion will often come with a discussion of the rate question. It is the topic which most users of power consider shrouded in the utmost mystery. It is unfortunate that rate tariffs in their printed form often appear far more complicated than their application actually proves them to be. It is true that very few, if any power companies, intentionally complicate their systems of rates with the object of confusing their customers. They have the following essential points to consider in devising their systems of charge: A long hour user (taking current, say 24 hours per day) can be sold profitably at a much lower rate per kilowatt hour than a short hour customer (taking current say two hours per day). An installation with a high demand (say 200 hp) cannot be sold profitably at as low a rate per kilowatt hour as one with a low demand (say 100 hp) provided, of course, each installation consumes the same number of kilowatt hours during a month or year. Paradoxical as it may seem, energy often may be sold at a loss to one customer at 10c per kwh and at considerable profit to an adjacent customer at 1c per kwh.

Basis of Rate Schedules.

Rate schedules are devised in almost every instance to cover these two variable costs. The "demand" or "readiness to serve" charge is intended to cover interest, depreciation, and other overhead costs on that portion of the line, sub-station, and power plant required, or set aside, to handle the customer's load, and which might be put to other use, were the customer disconnected from the lines. The energy charge is intended to cover operating costs, such as oil, fuel, labor and other running expenses. The demand charge is determined from the load connected either by suitable recording instruments or by reference to the rated capacity of the apparatus. The energy charge is determined monthly from a reading of the integrating or kilowatt-hour-meters, installed on the customers premises.

Demand Charges.

A clear preliminary understanding of the method of calculating the demand is essential. The more common practice is to charge the user a certain amount per kilowatt per month on the basis of the name plate rating of the apparatus. A 500 kw installation, for example, might be charged $1.00 per kw month or $500 per month in addition to the kilowatt hour charge as recorded by the integrating watt hour meter. This charge could justly be made whether or not any current was used by the customer during the month, and for as many months as the customer is connected to the power company's lines.

How Demand Charge Is Calculated.

Some power companies base their demand charges on the "peak loads" as recorded by curve drawing instruments. Where this practice obtains the method of determining and averaging the "peaks" should be clearly understood by both parties. The "peak" is the maximum load maintained without intermission over a specified period of time. It may be anywhere from 15 minutes to one hour. The demand charge is then determined at the end of the month by averaging a certain number of the peaks occurring during the month and multiplying the result by the charge per kilowatt of demand. It is obviously to the customer's advantage to measure each peak over as long an interval of time as possible and to compute the average from a large rather than a small number of peaks. The more progressive power companies are now basing their monthly demand charges for furnace loads on the average of the daily peaks of half hour duration or greater. Where the rate per kilowatt of demand has not been excessive, this method of charging has generally proved satisfactory.

Power Rates Easy to Understand.

The furnace user need not be confused by a study of the rate schedules submitted to him. If he will but state the various conditions under which he proposes to operate to the central station representative, he may have his rates figured and clearly explained very quickly. The monthly estimate of cost divided by the total kilowatt hours consumed will give the rate per kilowatt hour for energy under the conditions assumed. It is true, however, that this figure is not as important as it may seem. The most essential calculation for the furnace user to consider is cost of energy per ton of steel produced. This is determined by dividing the estimated or actual monthly power cost by the monthly tonnage of steel production.

Large Users Entitled to Lower Rates.

Two other characteristics of electric furnace loads that entitle users to lower rates are the amount of energy required and the character of power that may be supplied. Central station companies are always able to supply wholesale power at rates much lower than retail power. A single furnace may consume more energy than several hundred retail customers and yet require no more attention, or labor cost on the part of the power company than any one of its retail customers. Large generating units, transformers, power lines, protective devices, switchboards, and other electrical equipment, installed by power companies to handle furnace loads involve far less investment cost per unit of capacity than the equipment required for supplying small retail customers. Furthermore, the manufacturers of electric furnace apparatus usually supply the entire substation equipment, including transformer, protective devices and switchboard apparatus with the furnace installation so that the user may negotiate for his supply of power at the voltage of the power company's transmission line or generating station. This arrangements reduces the power company's unit investment cost far below that required to supply an equal load of retail power and lighting customers.

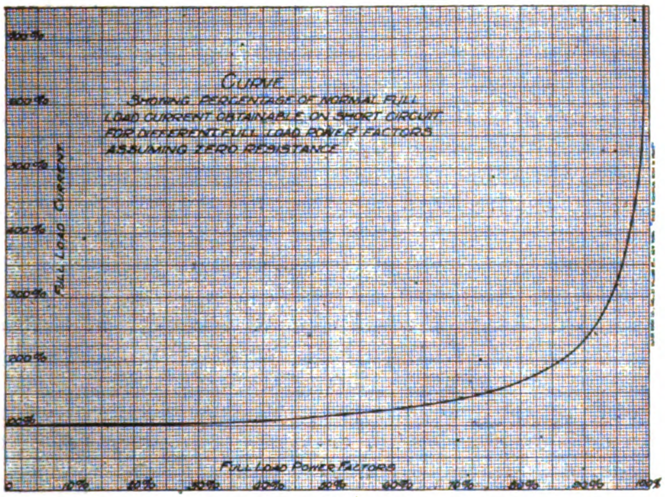

Fig. 1.

Character of Current Required for Furnaces.

Another feature which encourages the granting of lower rates to furnace users is that loads of this character do not require the close regulation which is always necessary on distribution circuits supplying retail power and lighting customers. Raw current, in fact, may be furnished from separate circuits without involving any cost to the power company for expensive regulating equipment.

Off Peak Power.

There are certain "peak load" hours of the day during which it is highly desirable to keep certain heavy loads off the power circuits. Most companies supplying electric energy are willing to quote considerably lower rates to furnace customers who can and will agree not to use their equipment at such times. The usual period is the two or three hours following sunset and oftentimes the furnace user can readily arrange his schedule so as to shut down his furnace during this time. A little friendly preliminary discussion may bring out this point and result in permanent advantage to both parties.

Furnace Power Factor.

An important phase of furnace loads for power companies to consider is the power factor. Some polyphase installations may have a power factor as high as 90 per cent, single phase long arc installations as low as 40 per cent and induction furnace installations as low as 30 per cent. Power factors below 50 or 60 per cent are almost always considered undesirable additions to the power circuits, especially if unbalanced or single phase furnaces, whereas 90 per cent power factor may be too high for some individual operating conditions. Smaller power stations usually favor power factors of 65 per cent to 75 per cent, whereas the larger ones may offer special inducements in the way of rate discounts for power factors maintained at 80 per cent to 90 per cent. Power factors may be varied somewhat by introducing reactance in the transformers through increased magnetic leakage or by the use of external reactance. The cushioning effect of such artificial reactance by power stations of limited generator capacity is sometimes considered advantageous even at the sacrifice of more desirable power factor conditions.

Curve No. 1 shows the effect of different power factors, as determined by the amount of total reactance in the furnace, transformer, and line, on the maximum amounts of current obtainable under possible short circuit conditions.

It will be noted that very high current surges are possible on circuits designed for power factors above 90 per cent.

Rate Schedules.

Each individual central station company seems to have its own standard schedules of power rates. It is seldom that two of them are worded alike, but the majority of those in effect in this country are quite similar in their application. The following "Wholesale Power Rate A" may be taken as a fair example of the make up and kind of rate submitted to large electric furnace users. Such schedules are generally made a part of a formal printed contract.

Wholesale Power Rate A.

Available to customers with connected load of 200 kw or greater.

Rate—

(1) Demand charge:
For the first 200 kw, $1.50 per kw per month
For the next 800 kw, $1.00 per kw per month
For excess over 1,000 kw, 75 cents per kw per month

Plus—

(2) Energy charge:
1.5 cents per kw hr for first 10,000 kw hr used per month
1.0 cents per kw hr for next 90,000 kw hr used per month
.8 cents per kw hr for next 200,000 kw hr used per month
.6 cents per kw hr for excess over 300,000 kw hr used per month.

Maximum demand determined, at option of company, from the customer's connected load (total of name plate ratings) or by suitable instruments—same to be calculated by averaging the daily recorded maximum 30 minute peaks of the month. The succeeding 11 months billing to be based on these calculations unless the connected load is increased.

Minimum charge for any month, whether energy is used or not, to be no less than demand charge.

Deduction of 5 per cent on demand charge when customer takes and measures current at power company's primary voltage.

Successive deduction of 5 per cent on total bill for payment within 10 days from date of bill.

No discounts for use of "off peak" power considered.

No deductions for maintenance of good power factor considered.

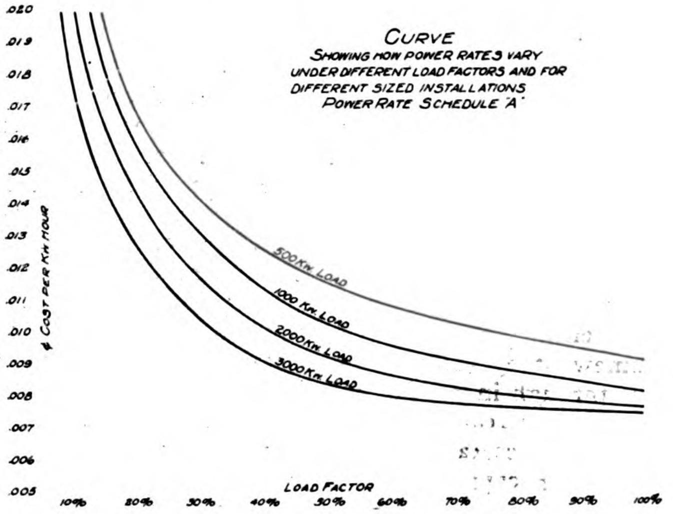

Fig. 2.

The curves, Fig. 2, show the average rates that would apply under various conditions of furnace operation figured on the basis of Rate Schedule A. For instance a furnace having a 1,000 kw demand and operating at 40 per cent load factor would earn a rate of $0.0115 per kw hour. The same furnace operating at 30 per cent load factor would earn a rate of $0.0133 per kw hour. Under the same conditions of load factor operation, a furnace having 3,000 kw demand would earn rates of $0.0092 and $0.0106 respectively, and the relative output of steel in each case would be in favor of the larger furnace. The application of rate schedule A as shown in Figure 2, therefore demonstrates that the larger the furnace load and the greater number of hours it is used during the month, the lower the rate will become.

Another point brought out by reference to the curve is that a small furnace operating a large number of hours during a month may earn a far better rate than a large furnace operating fewer hours. For instance a furnace having a demand of 1,000 kw and operating under 40 per cent load factor would earn a rate of $0.0115 per kw hour, whereas a 2,000 kw installation operating under a 20 per cent load factor, would earn a rate of $0.0147 per kw hour. In other words, the advantage is with a small furnace operated to capacity rather than with a large furnace operated intermittently.

Polyphase Versus Single Phase Furnaces.

Power companies, practically without exception, favor polyphase, rather than single phase loads, where large heating, power, or furnace loads are concerned. The standard present day practice is to generate and distribute electrical energy over three-phase circuits. The investment in power plant equipment and distributing lines is thereby largely reduced and polyphase power apparatus on the customer's premises is considerably less costly. Some of the older companies, in isolated instances, yet employ two-phase power circuits, but these are rapidly being changed over to three-phase distribution.

Of course, it is always possible to take single-phase current from polyphase lines, but immediately this is done, the other phases of the entire circuit including the generating equipment at the power plant become unbalanced; the load is not equally divided between the phases and serious impairment of the service and reduction of efficiency results.

Two-phase current may be taken from a three-phase circuit or three-phase current from a two-phase circuit by means of the well known "Scott Connection" of the transformers. This arrangement results in considerable loss of energy and impairment of the efficiency of transformation and requires the use of specially constructed transformers. It is quite apparent, therefore, that the use of three phase equipment works to the mutual advantage of the parties concerned—namely, the central station company, and the furnace user.

Energy Consumption per Ton of Metal.

So many conditions enter into the subject of energy consumption per ton of steel produced that only rough estimates and comparisons with actual installations can be made. Smaller furnaces naturally are less efficient than larger ones. Furnace design from an electrical, mechanical, metallurgical and heat engineering standpoint has much more to do with the amount of current consumed than is often realized. Basic operation requires more energy than acid operation. A longer period of refining is required. The heavy slags which have to be removed before pouring permit the escape of heat through the furnace doors and considerable heat is also absorbed and lost in the slags. Acid furnaces on the other hand oftentimes require no slagging whatever.

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The analysis, weight and form of the scrap or other material charged has a distinct bearing on energy consumption during the melting period. Heavy irregular pieces for instance melt more slowly especially in a furnace that is not equipped for rapid operation. The longer the time taken for refining and making the necessary additions the greater will be the current requirements. Again, it is well known that when pouring very small or thin section castings the metal has to be much hotter than when pouring larger more simple castings. The superheating required for small thin section castings therefore makes for higher current consumption.

It, of course, requires more time to turn out tool or alloy steels than to produce ordinary foundry castings on account of the longer period of refining necessary. Hence, the character and analysis of the product has a marked effect on the electrical energy used. In addition to these points it may be said that the number of hours of operation, the time between heats, the skill with which the refining is carried on and the necessary additions made, together with the ability and experience of the operator, has much to do with unit energy costs.

Foundry Operating Data.

The data in Table B shows the operating results of a 3-ton acid furnace turning out medium sized castings over a period of eight months of 24 hour operation. The costs are figured from Power Schedule A and are based on the first month's demand of 1,100 kw. To a central station man the rates per kilowatt hour earned by the furnace user may seem very low. When he considers however, that the furnace operation is continuous and observes the total monthly income, he will appreciate the valuable character of the load. The output of steel and the cost of power per ton of production should interest the steel maker.

Table B.

Electric energy consumption and costs on three-ton foundry furnace making acid steel for medium sized castings —24 hour operation:

Month	Kwh Consumed	Monthly Billing	Average Cost per kwh	Tons of Steel Produced	Cost per ton of Steel
First	362,000	$4,049.15	1.118c	603	$6.71
Second	524,000	4,754.75	.907c	904	5.29
Third	530,000	4,842.75	.901c	921	5.26
Fourth	613,000	5,362.05	.875c	1,104	4.85
Fifth	650,000	5,572.95	.856c	1,192	4.67
Sixth	555,000	5,031.45	.907c	991	5.06
Seventh	633,000	5,376.05	.849c	1,151	4.67
Eighth	597,000	5,270.85	.883c	1,076	4.90

Daily Output Versus Furnace Rating.

In selecting a furnace it is highly important to consider daily output as well as tonnage (per heat) rating of the equipment. This is a matter that concerns the power company furnishing the energy, as well as the furnace user producing the refined metal. With electric furnaces of equal tonnage rating, one may be capable of turning out five, another 10, and yet another 15 heats of refined steel of the same character in a 24 hour period.

From the power company's standpoint it may or may not be true that furnaces turning out the greater daily tonnage will produce higher demands on the power circuits. Seldom, if ever, does the demand increase in proportion to the furnace output and even though it did, the advantages far outweigh the disadvantages. Highly powered furnaces are generally sold complete with specially constructed transformers having exceptionally strongly braced coils. They are designed for a lower temperature rise under continuous operation and with a number of taps to permit wide variations of secondary or furnace voltage during the various operations. The latest designs are planned with the idea of producing a uniform well balanced power load. Only the novice in furnace construction will recommend the use of standard stock transformers for furnace work. It is true that the first cost of transformer and other electrical equipment may be greater, but the quick melting of the charge and subsequent rapid refining and superheating of the metal amply compensates for it. The assumption should not be made that any furnace may have its output augmented by simply increasing the transformer capacity, because such is not the case. The furnace itself must be so constructed from both mechanical and electrical standpoints, to handle the increased power and greater volume of heat without injury to the apparatus. In other words, furnace manufacturers must have a thorough knowledge of electrical and mechanical engineering, as well as of metallurgy to produce the best and most efficient apparatus. Too often the development has been one-sided and has been the cause of many of the popular prejudices which yet exist. The heaviest power loads come during the period of meltdown and it is obviously best to improve the efficiency as much as possible during this period.

There are numerous advantages accruing to the furnace user from a more highly powered equipment. In the first place, his investment cost may be reduced. A 1½-ton furnace of the more rapid design may do the work of a slower 3-ton furnace. It is well known that little or no refining of the charge takes place during the meltdown and the quicker this operation is performed, the sooner actual refining may be begun and the required results accomplished. Likewise, rapid refining may be performed with greater precision, increased efficiency, and with less losses than slow refining. Furthermore, it is apparent that the quicker the superheating process is carried through the less will be the losses and the sooner the metal may be poured into the moulds. With the heats coming frequently, less floor space is required for setting up the moulds. While the power cost of a furnace designed for rapid operation, may be somewhat greater than that of a slow furnace, the user is concerned only with the cost of energy per ton of metal produced. If it costs him a dollar a ton less produced in a rapid furnace, on account of his greater output, it is obviously to his direct advantage.

The more progressive power companies are beginning to consider the electric furnace load from a broader angle and to base their schedules on the furnace load as a whole, rather than on the load of an individual installation. They realize the possibilities for growth of the furnace business and appreciate that its encouragement will result in the installation of more furnaces, better average load factors, and attractive returns.

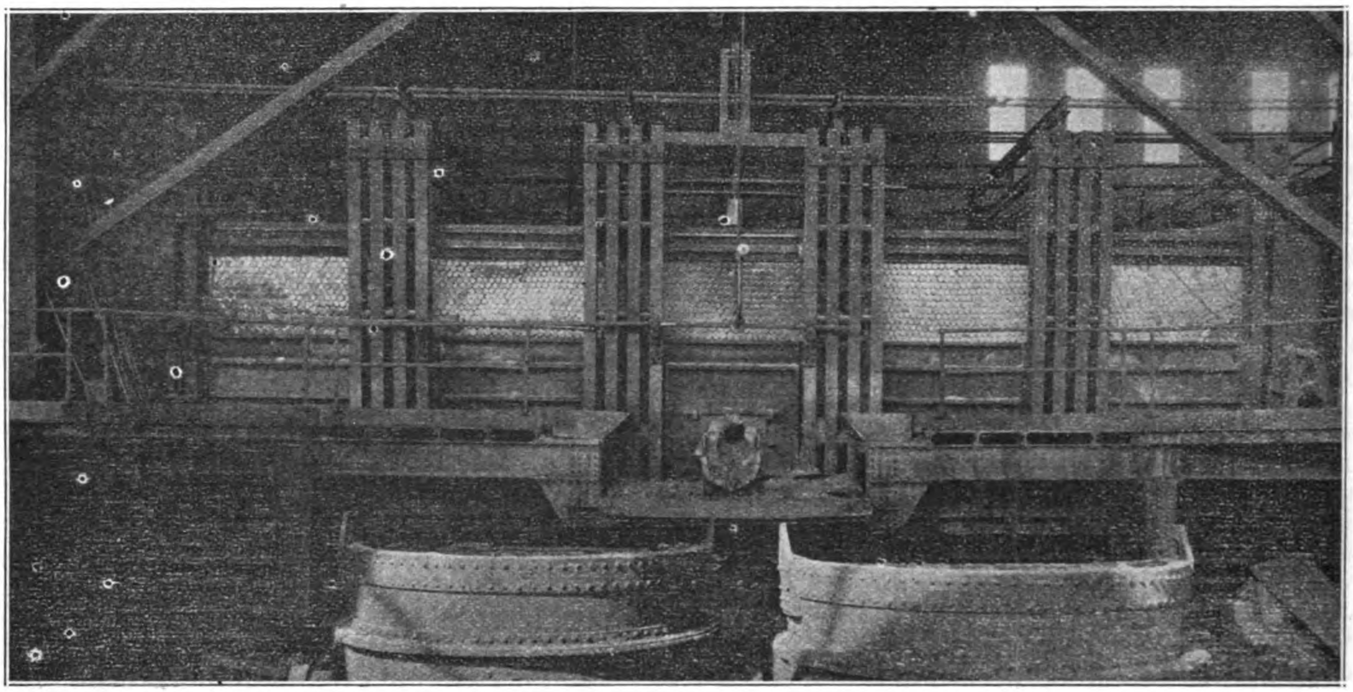

Fig. 1—Exterior of Metalkase backwall after a run of 28 weeks.

Open Hearth Practise With Large Units

Questions Concerning Special Practice on Large Open Hearth Units Answered—Double Ladle Practice Upheld—Experience With Metalkase Brick Shown by Interesting Illustrations.

By N. E. MACCALLUM,
Superintendent Steel Plant, Phoenix Iron Company.

To describe a modern open hearth plant would be to tell steel men what they already know, since all modern plants are more or less alike, composites of furnace, charging floor and casting pit, feeding in hot or cold raw material on one side of furnace, melting with natural or artificial gas, oil, pulverized coal or electricity, and tapping and pouring finished steel from other side. Such a description could be extended far beyond the allotted space, but if it were only a repetition of what has often been told before, it would not be of interest, and so it seems better to give a short description of two features which have been developed at this plant, (the Phoenix Iron Company), and which are not common to most plants. The first is our method of making steel in very large units, and the second is a new refractory, known as Metalkase brick.

Double Ladle Practice.

In the answers to the following questions I have endeavored to give the information for which we are frequently asked.

Q. Why do you tap one heat into two ladles?

A. That steel may be made in larger units than is possible with one ladle.

Q. Do you advocate the use of two ladles generally?

A. In all plants where capacity of hearth is greater than that of ladle or where hearth of furnace can be enlarged to capacity of two ladles.

Q. What is gained by making steel in large units?

A. An important saving in time, coal, and labor.

Q. Could not two heats of say 50 tons each be made in same time and with same amount of fuel as one heat of 100 tons?

A. No.

Q. Why not?

A. Because, while it would take longer to charge and melt 100 tons, the "working" or finishing would take no longer than 50 tons.

Q. Any other reason?

A. Two heats would have to be tapped instead of one and the time used in tapping and making up hearth for one of these heats would be used for melting steel.

Q. Any other reason?

A. Yes, the furnace would be cooled down twice instead of once and time and fuel would be required to heat it up again.

Q. Is it an established fact that steel can be made in less time in large units than small?

A. The whole history of the open hearth furnace has been one of gradual increase in capacity and each increase has shown a saving in time, labor and fuel.

Q. Can you substantiate that statement?

A. Yes, when our furnaces were of 30 tons

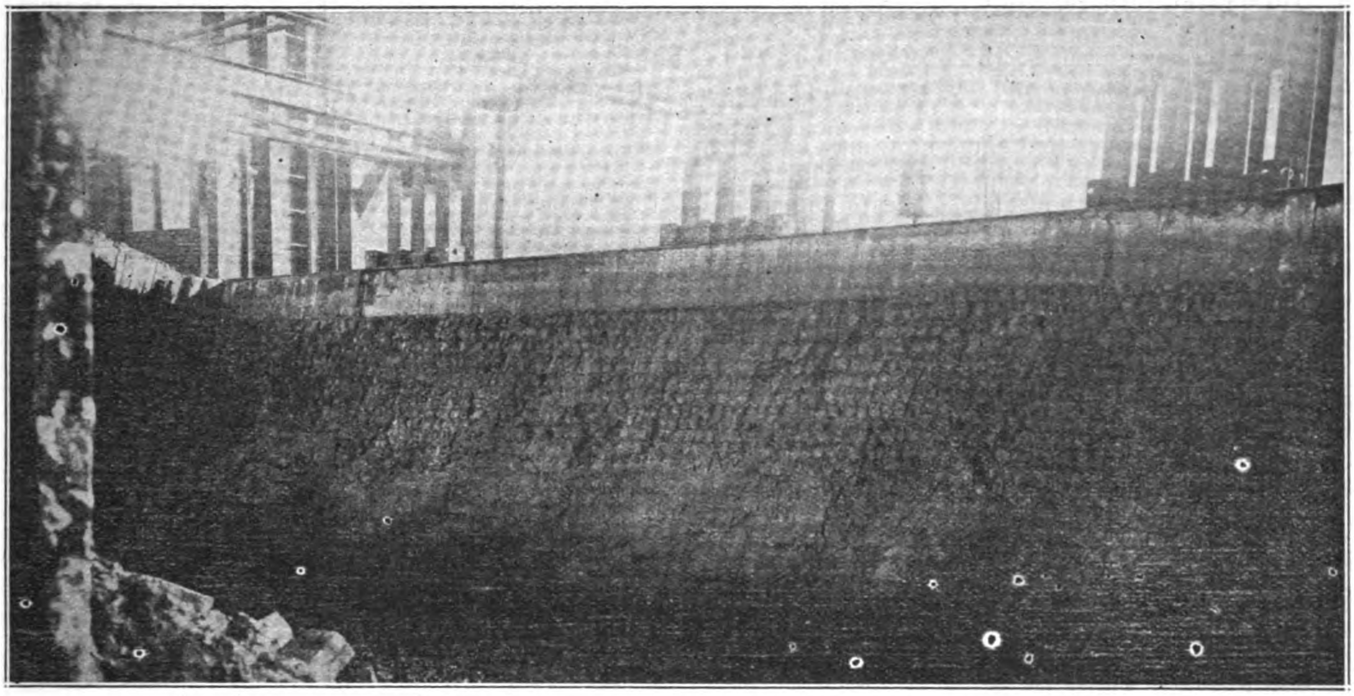

Fig. 2—Interior view showing hearth just after last heat had been tapped without any making up.

capacity it averaged 32.79 minutes to make a ton of steel. When increased to 40 tons it took 26.48 minutes to make a ton of steel. When increased to 50 tons it took 19.66 minutes to make a ton of steel. When increased to 115 tons, double ladle, it took 11.50 minutes to make a ton of steel. When increased to 130 tons, double ladle, it took 10.50 minutes to make a ton of steel. When increased to 165 tons, double ladle, it took 8.68 minutes to make a ton of steel.

Q. Are these net tons or gross tons?

A. Gross tons.

Q. Did you use any hot metal?

A. No, all cold.

Q. Then from figures just given the largest furnace made almost four times as much steel as the smallest furnace; what is the relative size of the hearths?

A. Hearth of small furnace was 17½ feet by 12 feet and hearth of large furnace was 42 feet by 15 feet

Q. Is the latter not an unusually large hearth?

A. No, it is about the size of most furnaces rated at 80 tons.

Q. Suppose that for a given period instead of charging your furnace to tap 165 tons, you charged only half that amount, what effect would that have on the product?

A. It would decrease the product.

Q. How much?

A. About one-fourth.

Q. Is there any practical way of demonstrating that steel can be made faster in large units than in small units?

A. Any furnace owner can readily do so by running a furnace one week on the usual size heat and the following week on heats of half size, and comparing results.

Q. Might not repairs to hearth or other delays impair the results?

A. Time of delays should not be included.

Q. What time should be included?

A. Only the time in which the furnace is actually making steel, that is, from the time when furnace begins charging until taphole is opened. This time should be reduced to minutes, divided by the tons of steel made, and the minutes per ton for each week compared.

Q. Then, if by doubling the charge in a furnace, you can increase the product one-third; what effect will that have on the coal or fuel used?

A. The fuel used over a period of say a week, will be the same whether furnace is working on small heats or large heats, but as the product in the latter case will be increased the fuel per ton will of course be less.

Q. Can you illustrate?

A. Take for example a furnace running on half heats producing 800 tons of steel, and using 720,000 pounds of coal (900 pounds per ton); on whole heats it would produce 1,066 tons of steel and the coal would be $\frac{720,000}{1,066}$ or 675 pounds per ton of steel.

Q. What led to the adoption of this double ladle practice?

A. We had rebuilt one of our furnaces and the hearth was so much larger than the capacity of one ladle, that to get the best results from furnace we decided to try to divide the heat, using a bifurcated spout to deliver the steel to the ladles.

Q. Is there any difficulty in dividing the steel so that each ladle will receive an equal amount?

A. Each furnace is provided with a controller so that if one ladle is getting more steel than the other, the stream to that ladle is partly shut off.

Q. Describe the controller and how it is operated?

A. It is an iron rod protected with brick the same as the stopper rod in the ladle, attached to a shaft mounted in bearings on furnace buckstayes. The shaft has a rotary and lateral motion and is operated by two levers at a safe distance from ladles.

Q. How many furnaces are you operating on this plant?

A. We have six furnaces, three of 125 tons and three of 165 tons, capacity, and all are equipped for this double ladle practice.

Q. Is there no danger that something may happen to the bifurcated spout and cause serious trouble?

A. We have tapped thousands of heats and have had no trouble, occasionally steel may splash over sides of spout, but nothing serious.

Q. Can a furnace equipped for two ladles be used for single ladle practice?

A. Yes, by blocking off one side of the spout.

Q. Do you consider steel made in large units as good as steel made in smaller units?

A. We have made close to 1,000,000 tons of steel in larger units, all of which has been tested chemically and physically, rolled and fabricated without showing the slightest difference from steel made in smaller units.

Q. Does not steel made in very large units show more segregation than in case of smaller heats?

A. Segregation only occurs while steel is cooling from the molten to the solid state and an ingot made from a 200 ton heat would show no more segregation than an ingot of similar composition and size made from a 5 ton heat.

Q. What is the capacity of furnaces being built today?

A. Most are rated at 80 to 100 tons, but capable of holding much larger heats but limited on account of using one ladle.

Q. What alteration must be made to a furnace in order to double the charge and use two ladles?

A. No alterations are necessary to any part of furnace. If hearth is not large enough it can be increased by extending chills.

Q. What is the usual charge for your furnaces with hearth, 42 feet by 15 feet?

A. From 350,000 to 400,000 pounds depending on condition of hearth.

Q. Now if by using this practice it is possible to increase the product of the furnace one-third and reduce the fuel and labor corresponding, why has it not been more generally adopted?

A. The only answer seems to have been the fear that "something might happen." As furnaces have increased in size from the pioneer of three tons, to 10, 20, 30, 40, 50 tons, the same fear has been expressed at each successive stage. When the furnace with two ladles appeared on the steel horizon many doubts were expressed, but years of successful operation without anything "happening" has done much to dispel fear and prejudice and more interest is being manifested in the double ladle practice now than ever before.

Metalkase Brick.

In a broad sense a Metalkase brick is a basic or neutral brick enclosed in a steel case and though it may seem paradoxical it is this steel case which imparts lasting qualities far beyond that of magnesite or any other known brick under the combined influence of high temperature and basic action. It was first placed upon the market in 1916, when stocks of Austrian and Grecian magnesite had become depleted and substitutes were being offered. These substitutes were mostly dolomite, sintered with open hearth slag, scale or ore, and in many instances gave and are giving good results for the purpose for which they were intended, that of making and patching hearths. Many attempts were made to make brick from these dolomatic preparations, but none proved successful, partly because the oxides which had been added to prevent slaking had reduced the refractoriness of the dolomite and partly because slaking had not been overcome. At the urgent request of a maker of one of these "mags" we made (and we were equally interested) some Metalkase brick using his prepared dolomite.

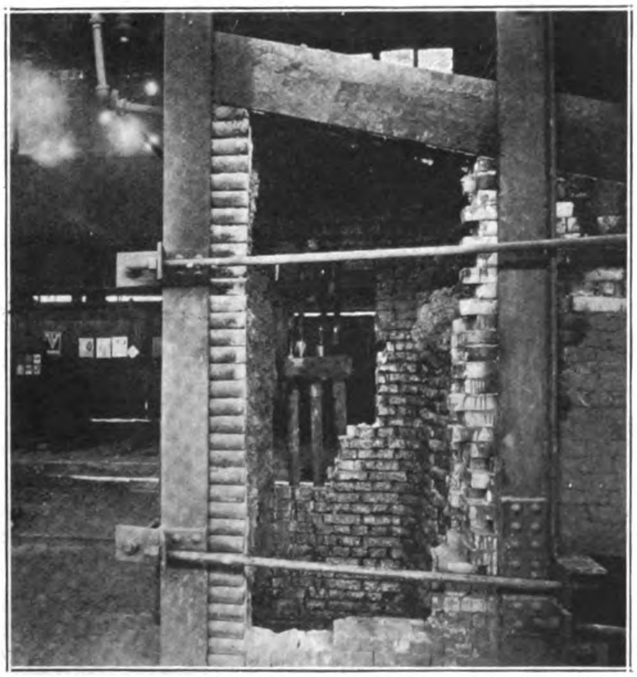

Fig. 3.

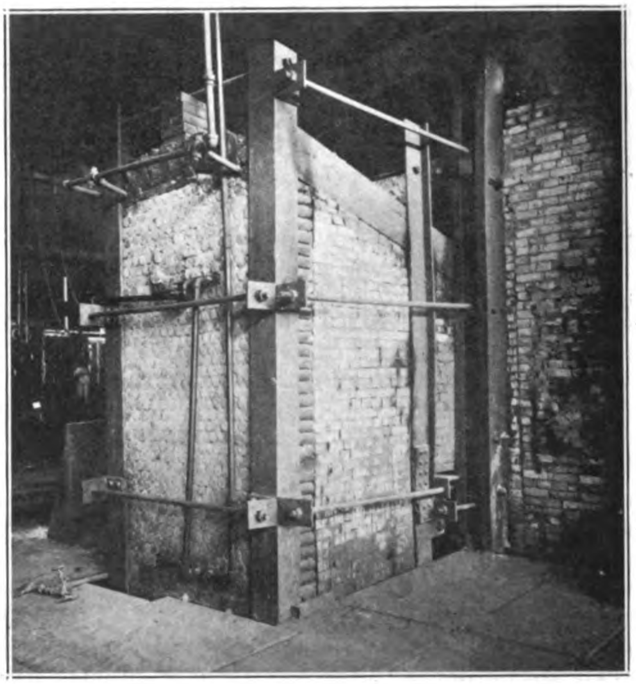

Fig. 4.

Fig. 3 shows the exterior and Fig. 4 the interior of Metalkase bulkhead after furnace had made 12,020 gross tons of steel.

The bricks when ready were used to build a panel, about four feet square in the back wall of one of our furnaces with the result that they burned out in 24 hours. I refer to these dolomite preparations with no idea of detracting from their value but only to show how difficult it was to get suitable basic material from which to make brick and also to explain why some of the earlier Metalkase brick did not meet expectations.

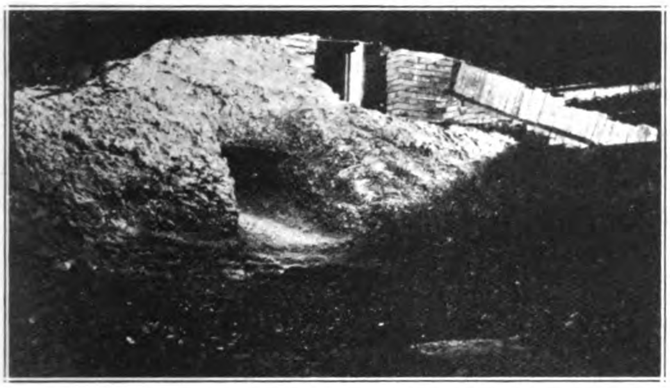

Fig. 5—Gas port constructed of Metalkase brick. Photograph taken from middle door while furnace was temporarily down.

The essential difference between a magnesite brick and a Metalkase brick is that the former spalls while the latter does not, and it is this quality which enables Metalkase brick to last from two to three times as long as magnesite brick. They are made either round or square, but for most purposes the round is preferable. The square bricks are laid dry and the round are laid in a mortar of pulverized magnesite. In general they are laid with the ends exposed to the heat and as the furnace approaches the melting temeprature the ends of the cases become converted into oxide of iron and fuse with the magnesite. Each brick burns fast to those adjoining until the entire wall becomes a solid unit.

The iron of the case, and the oxide of magnesia are both powerful bases so that there is no antagonistic action and neither is affected by the ever present vaporous oxide of iron, emitted by the melting charge, and which attacks silica brick with avidity. For this reason the interior of a basic open hearth furnace particularly the side walls and face of ports should be built of basic brick. This is especially true of the back wall which is subjected to splashes of basic slag when additions are made to bath or foaming when liquid pig is added. Many plants have experimented with magnesite brick backwalls, only to find that they gave very little longer life, if any, than silica brick.

Fig. 1 shows exterior of Metalkase back wall after a run of 28 weeks.

Fig. 2 shows interior of same wall. The photograph shows the hearth just as it was after last heat had tapped without any making up, from which it will be seen that the wash line is so slightly cut as to be hardly noticeable. It is of course evident that if a basic hearth is surmounted by a basic wall it will be free from the scouring action of silicous slag which would result from a silica wall and as a natural consequence should wear better and require less making up. As a matter of fact it rarely requires anything but raw dolomite. The weak point of a silica back wall lies just a few courses above the wash line, where it sometimes becomes so thin that the wall falls into the furnace. With a Metalkase backwall the conditions are reversed, the upper part of wall gradually wears thin, runs down and accumulates at and strengthens the base, so that the wall never falls in and will give days of warning before even a very small part goes in.

Fig. 5 shows view of gas port constructed of Metalkase brick. The photograph was taken from the middle door while the furnace was temporarily off for new roof over gas ports. Nearly all furnace gas ports are provided with a water cooler of some kind to support the arch, but runs down into bank and may cause breakouts. The sides do not cut out and the port remains original width when built of Metalkase brick.

The front of gas arch consists of a water cooler covered with Metalkase brick which also covers the silica arch behind the cooler. The banks on each side of gas port are built up with old Metalkase bats.

The most likely part of an open hearth furnace to first show signs of wear is the bulkhead of the gas port. The outgoing high temperature gases accompanied with oxide of iron impinge on the bulkhead and if built of silica it very soon wears out. Fig. 3 shows the exterior and Fig. 4 the interior of Metalkase bulkhead after furnace had made 12,020 gross tons of steel. During this time no repairs of any kind were made to the bulkhead and a close inspection of Fig 4 will show that the wear is almost negligible.

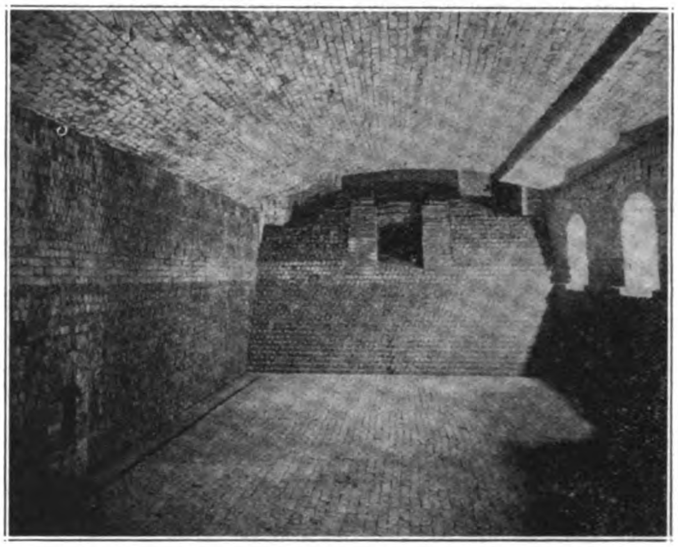

Fig. 6—Interior of open hearth furnace lined with metalkase brick. The floor is covered with 13½x2½ square Metalkase on end with the exception of the edges which are laid flat.

Fig. 6 shows interior of the open hearth furnace lined with Metalkase brick and floor is covered with 13½x2½ square Metalkase on end, except edges which are laid flat.

In the electric furnace Metalkase brick have been used with excellent results.

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Metallurgical Progress in Steel Industry

Progress in the Use of New Base Metals as Alloys—Notes on Investigations of Forging Reductions—Principles and Practical Methods of Heat Treating Brought to Date.

THE year 1919, and indeed, the period since our entry into the great war, has been notable, not so much for any radical departures in metallurgical processes or the development of new alloys, as for the broader and more intelligent application of those already known.

In many cases where the demands of war could be met only by bringing in companies with little if any previous experience in the manufacture of special products, such as shells and guns, difficulties and conditions of an unusual nature were encountered. These were brought up and discussed as something new, but in reality had long been known to those familiar with the subject.

New Rare Alloying Elements—In the field of alloy steels development has been proceeding in the endeavor to introduce for general industrial purposes steels containing special elements, hitherto of quite restricted use, such as tantalum, zirconium, cobalt, and molybdenum.

In this article it is pointed out that no radical departures in metallurgical processes were developed even during the war, but that what progress was made was rather a more intelligent application of the processes already known. So many new companies were started during the war that undoubtedly many processes were heralded as being new when actually they had fundamentally been known for some time.

Tantalum has been employed to increase the hardness of files, cutting tools and other instruments, but its use is rather limited.

Zirconium, a newer element to be alloyed with steel, is supposed to increase the hardness and decrease the susceptibility to shock for armor plate projectiles and similar purposes, but few real data are available. Conflicting claims are made by different investigators. Further researches are needed before definite claims can be made.

Cobalt under 4 per cent acts in a manner similar to nickel in conferring toughness, producing an alloy slightly harder than nickel steel. When added to high-speed steel it is claimed to increase the life of the tool. It is used in stellite, for example, which contains about 55 per cent cobalt.

Molybdenum has been used for many years as a substitute for tungsten in high-speed tool steels. Within the last two or three years it has been added to steels containing chromium, such as armor plate gun shields, armor for tanks, liners for large guns, in automobile steels and for springs. In amounts from .20 per cent to 1.00 per cent, in combination with chromium, it raises the elastic limit of such steels. This property is developed after heat treatment, in which it is claimed a wider range in temperature is permissible than with many other alloy steels. Up to the present time it has been more extensively used in Europe than in America.

Final judgment as to the uses of these and other comparatively rare or unusual elements cannot be passed until further work has been carried out.

Forging Reduction—In specifications for guns and other forgings of high quality it has long been common practice, both in this country and abroad, to include a requirement for a minimum ratio of reduction from ingot to forging, usually of four to one. This was based on the idea that if a little work was good, still more would be better. Investigations conducted here, in England and in France have brought out the following general rules:

1. A certain amount of forging is necessary to break up the original dendritic structure of the ingot formed during solidification.

2. For tensile tests taken parallel to the direction of forging extension, a large amount of reduction is beneficial to the elongation and the reduction of area.

3. For transverse tensile tests (i.e., "across the grain" or normal to the direction of forging extension) the smaller the amount of reduction (beyond what is necessary to break up the dendritic structure) the better for the ductility.

Of the same nature is the problem which arises in the manufacture of gears from forged blanks, particularly when nickel steel is used, owing to the more or less pronounced "fiber" in the direction of forging or rolling. If this fiber extends across the gear face there will occur two diametrically opposed points of maximum strength, with minima also at 180 degrees to each other and at 90 degrees to the maxima. This can be corrected by upsetting a block at right angles to the original direction of extension, as then the so-called fibers will be caused to assume a radial direction and will be more or less matted together, giving equal strength at all points on the rim.

Heat Treatment.

While no radical departures in the practical application of heat treatment have occurred, attention should be called to the considerable advance in the

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development of the practical, as distinguished from the purely theoretical principles necessary for successful operation. This beneficial condition was largely brought about during the war by the need for intensive production along special lines by companies which, under previous normal conditions, had had little or no such experience. Even yet there are many cases where the general principles are ignored or imperfectly understood. Attention may therefore be profitably directed to certain principles which are of greatest importance.

Conditions Involved in Industrial Heat Treatment.

Continuity and Regularity of Operations—A good many years ago it was conclusively demonstrated by H. M. Howe that the enormous tonnages produced by American Bessemer plants were due more to the elimination of delays than actually to speeding up the process itself; and, further, that the regularity of operation resulted in a positive improvement in the quality and uniformity of the product, instead of a detriment, as was at one time popularly believed. Again, it can readily be calculated that even when a record tonnage of rails is rolled, the total length produced is only a fraction of what would correspond to the peripheral travel of the rolls; hence increased production can be brought about by decreasing the interval between consecutive billets, without speeding up the rolls. To carry out this same principle in heat treatment or any other industrial process, the apparatus must be so designed and the various steps so coördinated, that the flow of material is steady and uninterrupted. Delays may be of two kinds: (a) those due to breakdowns of equipment, lack of supplies, and so-called "acts of providence;" and (b) those caused by mistakes, such as improper heat treatment, necessitating repeating the same operations for a portion of the material. The first may be considered as more or less mechanical in their nature, and steps for their prevention are fairly obvious. The second require careful planning and, frequently, an initial outlay, the advantage of which is appreciated only when balanced against the total cost. As an illustration may be cited the separation of heats in order to permit of eliminating any which are inherently defective and, further, of classification by composition for heat treatment. Allowing heats or lots of steel to become mixed, with consequent loss of identification, may easily result in the rejection of a greater amount of material than would otherwise be necessary.

If it were possible to obtain in bulk material of a single definite composition, a single method of heat treatment could be established. Even the highest quality of crucible tool steel, which is manufactured by pounds, varies in composition from potful to potful and also from one part to another of a small ingot. In the case of open hearth steel, measured in tons, the unavoidable variations must obviously be much greater. Therefore very close limits in composition can be regularly secured, not by a process of steel making, but only by a process of elimnation after the steel has been manufactured and analyzed. This would result in excessive costs, as one of the advantages of heat treatment is its flexibility in correcting reasonable differences in composition to meet specified physical requirements. Standard engineering specifications are now being drawn up with a better knowledge of these conditions, and only where they are ignored, or in certain very special cases, are greater precautions necessary.

Material of a given grade within practical manufacturing ranges in composition will permit of the equally necessary industrial variations in heat treatment. Thus it was found that shrapnel cases varying 20 points or even more in carbon, in addition to the usual ranges in the other elements, could all properly be quenched from a single temperature (or usual range of temperature). The variations in composition were corrected by adjusting the drawback temperatures according to two, or at most three, divisions based on the contents in carbon and manganese. Checking such classification by treating and testing a few samples from each heat was frequently the means of avoiding retreatment of an entire lot. Since the drawing operation is chiefly responsible for the control of the physical properties, it is better, if in doubt, to have the temperature too low rather than too high, as in the former case a second draw at a somewhat higher temperature is all that is necessary, while in the latter case, since the material is now too soft, both the quenching and the drawing operations must be repeated.

New alloying raw elements such as tantalum, zirconium, molybdenum and cobalt, are being used in steel manufacture. The author however remarks that final judgment as to their uses cannot be passed without the light of further investigation.

Fundamental principles of forging and heat-treating are also dwelt upon in this article.

Supplementary Equipment—To assure a stated output, sufficient additional equipment must usually be provided to allow for a certain percentage which will normally require retreatment, or special treatment due to composition slightly outside the regular range.

It is desirable, whenever practicable, to have any equipment composed of a sufficient number of separate units in order that, in the case of a breakdown, or when minor repairs are necessary, the output will not be seriously affected, as would be the result were there only one or a few large units.

Uniformity—This term is to be taken in a relative rather than in any absolute sense, and is to be striven for and maintained within limits which can be established between essential quality of product and cost.

Temperature Measurements—Pyrometric apparatus of a refinement needful for scientific laboratory experiments may be quite unsuited for shop work.

Pyrometers must frequently be checked in order that their degree of accuracy (or inaccuracy) may be known at all times, as it is better to rely upon visual estimation of temperature than upon a pyrometer which, however accurate when first installed, may in the meantime have become inaccurate. It is better to determine the time of day within about an hour either way from the position of the sun, than to allow only a few minutes for catching a train trusting to a watch which may demand equal latitude.

Furnace Accuracy—It might be possible to secure good results in heat treatment with very cheap and inefficient apparatus, under the personal supervision of an expert employing all manner of special precautions. However, when it comes to relying upon an ordinary foreman and gang of laborers, only specially designed apparatus will serve. The greater initial financial outlay which this entails is much more than offset by the saving effected in costly rejections and retreatments, greater regularity of output, and quality of product.

Furnace Temperatures and Object Temperatures—Frequently it is deemed sufficient to determine the temperature of the furnace only, with the assumption that this is all that is required to indicate that of the charge. This condition may be partially necessary with a furnace of the continuous type when one or more pyrometers are permanently installed, and which could not be brought into direct contact with the charge or too close to it, without danger of being injured. Here the element of time becomes a predominant factor, and may cause serious trouble, particularly if superimposed on inaccuracies of temperature measurement and of furnace operation. Frequent direct checks of the temperature of the material itself are almost indispensable.

Recording pyrometers—These are of value, not only as affording a continuous record of furnace conditions, but also for their preventive effect in inducing constant care and watchfulness on the part of the operators, and thereby materially reducing the human factor.

Uniform Effect and Penetration of Heat Treatment—In the laboratory experiments which formed the basis for industrial work, the size of the pieces treated was necessarily so small that the factor of mass was almost negligible. This factor applies not only to pieces which are individually of large section but also to material treated in bulk even when composed of small pieces or long pieces of small cross-section. This fact is too frequently disregarded. In addition to making sure that the entire piece or charge is at practically the proper temperature throughout, a sufficient interval of time must be allowed to permit the completion of the rearrangement of the internal structure in relation to the given temperature. This applies both to heating for quenching and heating for drawing back. When sufficient time has not been employed for "soaking," the physical properties developed may be much below normal. Under such circumstances instead of increasing the time, the temperature both for quenching and for drawing may improperly be raised with no substantial benefit, or even with decided injury.

Structure.

Coarse grains or injurious structures, produced by heating to high temperatures or developed during solidification can sometimes be broken up by a refining treatment consisting of heating and slow cooling, or more effectively when rapid cooling is employed, and in some cases, even, only by the assistance of hot working.

As is well known, hardening is the result of heating a suitable grade of steel above the critical temperature or range followed by rapid cooling. To remove excessive brittleness or strains, it is reheated or tempered to some temperature below the critical, selected according to the effect it is desired to secure.

Carbon Condition—While no change in grain size, or increase in hardening, is brought about by reheating below the critical range, there may be a marked effect on the composite structure, termed pearlite, consisting of interspersed iron (ferrite) and carbide of iron (cementite). In such cases, particularly on prolonged heating or very slow cooling, these two constituents tend to separate from each other (segregate in a microscopic sense) with a corresponding decrease in the physical quality of the steel. The beneficial effect of quenching a piece after drawing, instead of allowing it to cool slowly can, in part at least, be attributed to the decrease in this segregation, an advantage which can be turned to profitable account industrially.

Strains — Irregularity of heating and cooling, whether due to the method employed or because of the size or the shape of the object, may largely be corrected by reheating either below or above the critical range (depending on circumstances) followed by slow cooling. This is of advantage in the prevention of warping when the object is subsequently machined. Where the reheating follows quenching, and is limited as to temperature in order to preserve certain physical properties, it is advantageous to select a reasonably high carbon content or such a type of steel that the temperature may be as high as possible. This is especially true of parts subjected to repeated stresses and shocks. As a very general rule the higher the drawback temperature the better.

Faulty Heat Treatment—Even under the best conditions strains will increase (a) the more severe the treatment, (b) the greater the mass, and (c) the more irregular the section or shape. In addition, there are other conditions which can largely be guarded against. Surface seams or laps may open up on quenching and cause the crack to penetrate deeper.

Material containing bad seams should be rejected, while slight seams can profitably be machined off before quenching. Pipes, internal cavities, and excessive segregation or unsoundness will usually cause cracking or splitting.

It should be realized that heat treatment is generally an intensifier. In some cases it may be made to improve slightly defective material, but in general it will make good material better and bad material worse.

1919 Sees Improvements in Refractories

Past Year Shows Less Demand but Better Product—Three Large Technical Societies Evince Marked Interest in Refractories — Important Standards Set.

By R. M. HOWE,
Mellon Institute of Industrial Research, Pittsburgh, Pa.

During the war there was such an unusual call for all kinds of refractories that it was almost impossible to meet the demand. In order to do this, it was not only necessary to replace the minors and plant men who entered the service, but also to increase the entire personnel of most of the plants. This condition was particularly emphasized in the fire brick industry because such a large percentage of the production cost is attributed to labor. Consequently, it was necessary to make use of new men, to secure a greater production from the older men, and to keep the good will of all. It was natural, therefore, in many cases that bricks were shipped which were not up to the usual standard and even "cull" bricks were knowingly bought.

During the past year, however, fewer by-product coke ovens have been constructed; the production of metal has diminished; contemplated construction has been discontinued, and the demand has not been so great. The effect of such a condition has made itself noticeable in many ways.

The refractory materials used in metallurgical furnaces are of utmost importance to successful operation, and it is encouraging to note that the author points out in this article that the quality of these materials is being given much attention. The difficulties experienced during the war have been removed to a considerable extent and steady progress is being made through the efforts of engineering societies interested in developing methods of analysis and testing. Such investigations should bring about standardized methods.

There are very few of the newer men about the plants or mines at present who can not be considered experinced brickworkers; many of the older men have returned from service, and there is not the necessity for maximum production. Such a change in conditions can do nothing else but improve workmanship and it is a fact that refractories made today are equal to or better than those made before the war.

A representative of a large foreign steel company made the remark in an American brick plant during the past month that "those (pointing to some silica bricks culls) are as good as the run of brick we buy in——."

Not only has the average caliber of the labor employed increased, but the general plant conditions have been improved. In several cases work started in 1914, was discontinued for four years, but this has been completed during the past year.

One distinct recent improvement other than those usually made concerns the manner in which fire clay and water are mixed. The universal practice has been to mix these ingredients in a pug mill or pan until the operator deemed the process complete. Consequently, the proportions of water and fire clay is quite variable and this variation exerts considerable effect on the dimensions, strength, uniformity and structure of the finished product.

The Schaffer poidometer has been applied recently to controlling the addition of water. The principle upon which it operates is very simple and hence the device is easily controlled. The charge of clay is weighed as it is transmitted to the mixing machine on a conveyor belt. The amount of water added is controlled automatically and varies with the weight of the clay. The proportions are said to vary less than one-half of one per cent. Although the success of this device is not assured, its installation is a step in the proper direction and should make possible the production of a more uniform, denser product with no greater expense.

Work of Societies.

The three societies which have taken the most interest in the field of refractories are the American Society for Testing Materials, the American Ceramic Society and the American Chemical Society.

The American Society for Testing Materials through its committee C-8 has developed tentative methods for the analysis and testing of refractory materials. The work has progressed slowly, but nevertheless, tentative methods have been proposed for the slag, load, porosity, volume change and fusion tests and for the chemical analysis of fire clay, ganister, magnesite, chromite and the corresponding bricks. The exchange of ideas and the standardization of methods brought about by this society has been of great value in the work of the Refractories Manufacturers' Association at the Mellon Institute of Industrial Research.

The association members have fully appreciated the value of the investigations conducted at that institution, whether they apply to a certain specific problem or to one of general interest, and consequently the technical staff has been gradually increased to meet the manufacturers' demands. This work has been described elsewhere and hence will not be discussed at this time.

The American Ceramic Society has furthered the interest in this field in several ways. It has established a "refractories division," whose members aim to investigate researches, secure papers, and keep in close communication on the subject. They have also decided to help develop the plan of R. C. Purdy for the establishment of a national bureau for the study of "superior refractories." It was shown, in presenting this plan, that the subject was of vital interest to all, and of too complicated a nature to warrant its study by any individual corporation or group into which they might be combined. In view of these facts, it appears to be no more than logical that a bureau with government backing should attempt the same. Such a bureau would probably aim to establish the uses for the common refractories and to develop electric furnace products for extending the present limits.

Standardization.

There have been three distinct tendencies in this field, one concerning testing, a second concerning sizes, and a third concerning quality. The standardization of tests has already been mentioned in connection with the work of the American Society for Testing Materials. The standardization of quality was instigated by Dr. A. V. Bleininger, of the United States Bureau of Standards and his tentative definitions for different grades of refractories were later promulgated through the War Industries Board. A great amount of preliminary work was done before these were written and consequently they possess more value than the usual specifications.

The standardization committee of the Refractories Manufacturers' Association has probably been the most successful from the practical standpoint. This committee found that some 75 so-called 9-inch sizes (including arches, wedges, keys, etc.) were being used in conjunction with the standard 9 x 4½ x 2½ straight fire brick. After an enormous amount of investigation and study the number of sizes was reduced to 29, and these 29 shapes are filling nearly every need formerly supplied by the larger number. The economy to both manufacturer and user is self-evident and needs no discussion.

Silica brick sizes were also reduced to 22 sizes, the greatest changes having concerned the 12 and 13½-inch brick used in open hearth and blast furnace roofs.

Other shapes for particular uses are being standardized in this same way and such work, when complete, should considerably decrease the number of sizes now kept on hand at the plants.

New Laboratory at Union Drawn Steel Co.

Large Industrial Plant Installs Complete Works Laboratory. Description of Building Arrangement, Instruments and Other Equipment for Methodical Testing of Product and for Research.

IT is unnecessary for the writer to call the attention to the fact that works laboratory is coming into its own, for anyone familiar with work practise of almost any manufacturing industry, realizes how important an adjunct the laboratory is becoming, and, in fact, has been so considered by live manufacturers for years, but, the late war furnished the impetus for the more complete chemical and physical testing of materials than had been the general practise before. This demand was largely brought about by the fact that so many experienced and inexperienced technical men were placed in position of responsibility, where guess work and "rule of thumb" methods were not tolerated, to illustrate, it was not enough to suppose that a Liberty motor crank shaft possessed the correct physical properties required by the designer, but, it must be shown that it did by laboratory tests as far as possible, and so on down through the whole list of the various products used in the war.

It was during this period, as well as since, that the officials of the Union Drawn Steel Company, as well as the laboratory force, recognized the need for the enlargement of their laboratory, and, for additional equipment. To that end, a brick building, containing about 1,470 square feet floor space, was provided, and. while the finishing touches have not been added, the following description will be substantially correct.

The room marked "furnace room," Fig. 1, contains approximately 460 square feet and will be used for miscellaneous and experimental work, not regularly handled in the other room, such as, case hardening and other heat treating experiments, experiments in pyrometry, checking of work's pyrometers, using the Leeds & Northrup potentiometer system as standard, which has been checked by the melting points of salt and also by the melting points of metals of extreme purity. Other pyrometers are also used as secondary standards, when satisfactory accuracy can be obtained by their use. Other apparatus consists of a barium chloride furnace heated by gas, a surface combustion furnace four feet long, also using gas for fuel for the heat treatment of bars to develop their physical properties. An electric muffle furnace for shorter pieces is in use, the temperature of which may be very closely controlled. The quenching tank will contain water and an oil bath containing a coil of pipe, through which water flows to keep the temperature of the oil down. Cupboards for the storing of surplus chemicals are located in this room. In one corner, a dark room, containing running water is provided for the printing and developing necessary in the micro-photographic examination of steel as an aid to the proper interpretation of the results of heat treating. Near the dark room, is located an electric driven polishing machine with the necessary polishing powders for the preparation of the steel specimens previous to etching .

The machine room contains approximately 450 square feet and in this room is located a Riehle 100,000 pound testing machine, equipped with autographic recording mechanism. This machine is direct driven by 7½ hp, 220 volt, 60 cycle, 3-phase motor, and, can be used for compression and transverse tests, as well as for tensile tests. A feature, which was found very useful during the war, was a bending machine, manufactured in our own shop for making bend tests of various sized bars. We have bent rounds 1¾ inches in diameter to nearly a perfect U, taking 50,000 to 55,000 pounds to do so. A Brinell machine is in use for hardness determination, as is also the Shore sclerescope. Both instruments are constantly used in checking up heat treated work, as well as the testing machine.

This laboratory employs almost entirely the standard test piece of .505 inch diameter by 2 inch gauge length, as it is found to give the most consistent results.

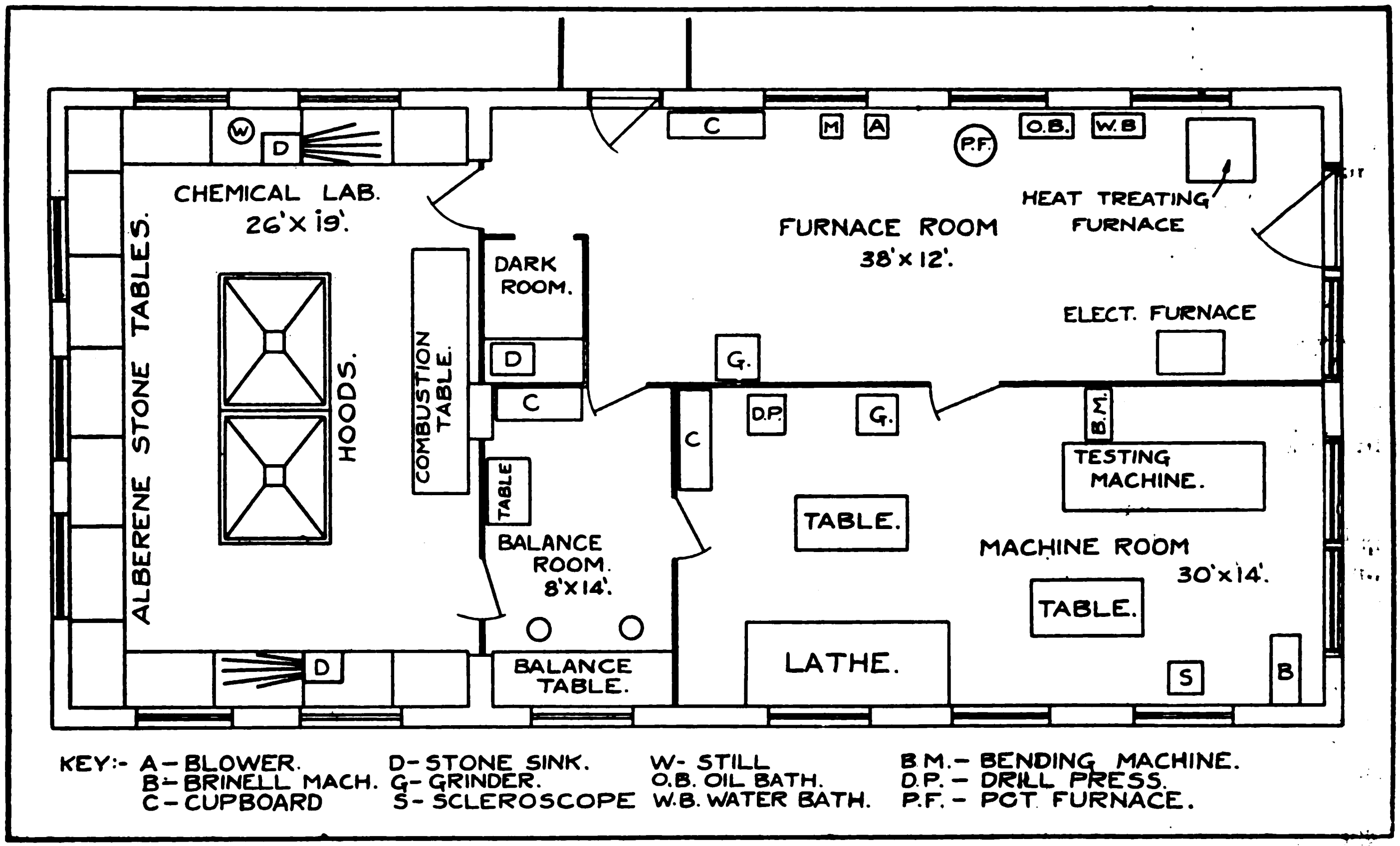

Fig. 5—Plan of new laboratory building at Union Drawn Steel Company's plant.

A 16 inch screw cutting lathe, belted to a 5 hp, 220 volt, 60 cycle, 3-phase, synchronous, variable speed motor is in almost constant use, either in the sampling of material for analysis, experiments in die making, turning of test pieces, or in other experimental work.

Many samples are taken more quickly with the drill and a 16 inch Canedy-Otto sensitive floor drill is used, direct driven by 220 volt, 60 cycle 3-phase motor.

For the cleaning of rusty and heavily scaled samples, a United States electrical floor grinder, direct driven by 1 hp motor, is found very efficacious, as well as for grinding tools, and, the miscellaneous work in the testing room.

The chemical laboratory contains approximately 490 square feet floor space and is splendidly lighted by daylight as well as at night. The electric lighting system consists of one 200 watt lamp at each end, and, as side, or individual lights, six 50 watt lamps to be used as required. Shelves or work tabling, 30 inches wide, composed of alberene stone 1¼ inches thick, suitably mounted on heavy brackets is provided. At each end of the room is located an alberene stone sink with grooved drain board. At each sink are hot and cold water spigots. The center of the room is occupied by a hood 12 feet long by 4 feet wide, made by Leonard, Peterson Company, the working table of which is covered with alberene stone and is divided into four compartments. Nearly the whole of one side of the hood is occupied by sulphur determination apparatus. Of the other side, one-half is used for dissolving samples for nickel, chromium and vanadium determination; the other one-half for phosphorus determination. The sides, used for alloys and phosphorous determinations, have running water, and cooling baths. Thus nearly all hot acid solutions are cooled under the hood, and, in a great measure, the atmosphere of the laboratory is quite free from acid fumes.

The laboratory contains the usual apparatus used for the analyses of iron and steel, among which may be mentioned electric combustion furnaces, electric centrifuge for approximate phosphorus determinations, self-filling burettes, and, in lieu of direct current, an electric rectifier is used to produce direct current for electrolytic determinations, using platinum electrodes, or platinum anode and mercury cathode.

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Electric vs. Open Hearth Furnace Practise

A Comparison of the Cost of Electric and Open Hearth Steel Made From Actual Running Cost—Twenty-ton Oil-Fired Open Hearth and Six-ton Heroult Electric Furnace.

By E. H. BALLARD.

THE author of this article read a paper before the American Foundrymen's Association from which the following is abstracted. The data is taken from an investigation on electric furnaces made at the Lynn works of the General Electric Company. Acid open hearth furnaces had been in use for 26 years at this plant. In order to maintain production from the open-hearth furnaces at reasonable cost, and to keep pace with the labor shortage, many changes have been made by rearranging the entire open-hearth department, installing traveling cranes with lifting magnets, and a mechanically operated charging machine.

Fuel oil economies have been carefully studied, so that under favorable conditions it has been possible to produce a ton of steel with 37 gallons of oil per net ton of melt. These factors have made it possible to produce molten metal in the ladle much cheaper than could be done in the electric furnace.

More Difficult Work Necessitated Electric Furnace.

With radical changes in design of much of the product, the engineering department began calling for work difficult, if not impossible, to produce in the open-hearth furnace, particularly where a small quantity of alloy or special carbon steel was required. Producing small heats in a 20-ton open-hearth furnace is not economical; neither is it good business to make a full sized heat requiring special mixes, using only a small portion for the particular work desired, and pouring the balance into regular commercial work.

From the investigation made of the electric furnace, it seemed that this process would meet the particular requirements. The latter part of 1918 the installation of a 6-ton basic lined Heroult furnace was completed. Regular production was commenced in December, 1918, with an entirely inexperienced organization. The furnace was operated for four months, day shift only, enabling us to secure actual cost data.

The open-hearth department, having been organized for the past 26 years, and made up of many men who had been with the foundry for practically the entire period, it goes without saying that to contrast the operating expense of the old organization of the open-hearth with the new organization of the electric furnace, we should not be too severe in our criticism when analyzing operating costs.

The writer believes, however, foundrymen will agree, from the figures which follow, that the costs of the electric furnace are comparable when it is considered that the product of the electric furnace is superior and is fully meeting chemical and physical requirements. It will be noted that in analyzing costs the kilowatt consumption per net ton in the ladle is 720. This apparent high consumption is due to the fact that 60 per cent of all heats are double slagged. A very conservative estimate for single slag heats, operating according to our practice, is 650 kilowatts. The power charge of $1.25 per 100 kilowatts is abnormally high. A material saving in labor costs could be effected by employing a mechanical charging device which would reduce the charging time.

Analyzing Comparative Costs.

The cost of special metals for the electric furnace was $2.28 per net ton. For actual comparison we should eliminate the charge for nickel and copper, replacing 1,749 pounds with ordinary scrap. This would reduce the special metal charge 49c per net ton.

In analyzing the expense items of the electric furnace, a current charge of $1 instead of $1.25 per 100 kilowatts should be assumed. This item would be reduced $1.80 per net ton of melt. The fuel oil charge for the open hearth is $7.90 per 100 gallons. A very conservative price for oil would be $5 per 100 gallons. The fuel oil consumption, is 44.4 gallons per net ton of melt. This is high due to furnace operating on short time. If we assume a consumption of 37 gallons per net ton of melt at 5 cents per gallon, according to our practice, the fuel oil cost per net ton of melt would be reduced $1.85.

With the open-hearth furnace operating full time a number of cost items would be materially reduced, as follows:

Direct labor	0.24 per net ton
Expense labor	0.50 per net ton
General expense	0.75 per net ton
Depreciation	0.25 per net ton
Repairs	0.24 per net ton
	1.98

It should be stated that these figures are not estimates but are actual tank measurements, checked by accurate oil meters, and include the heating of ladle, and week end heating up of furnace.

Summary of Costs.

The writer believes that foundrymen will agree that the exceptions above noted are not in the least exaggerated, and are shown for the purpose of presenting the best comparison that the figures will permit, assuming both furnaces are operating under normal and reasonably full time conditions. With the reductions, as above noted, a summary of costs is as follows:

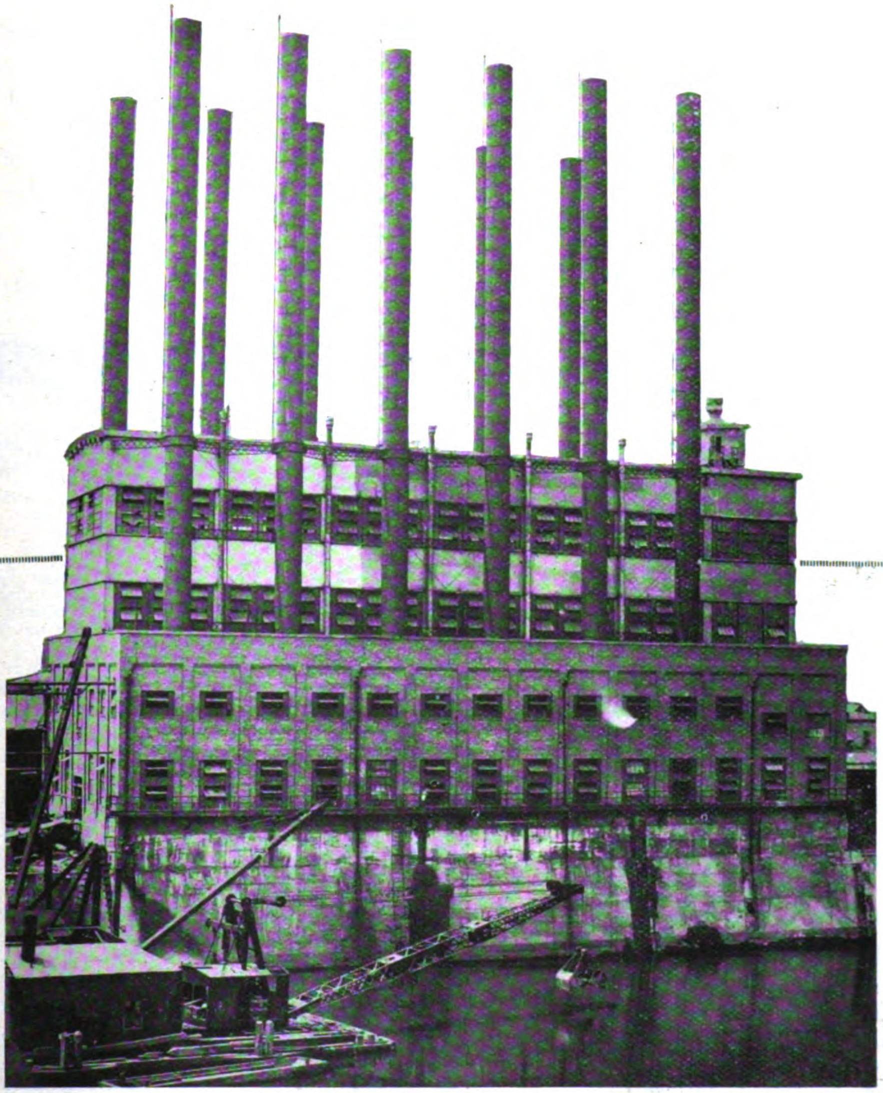
	Electric furnace	Open-H'th Fur.
Total metal cost	9.52 net ton	14.28 net ton
Special metals	1.79 net ton	3.52 net ton
Expense items	21.58 net ton	6.60 net ton
Molten metal cost in ladle	36.57 net ton	32.55 net ton

The costs were given in full in the authors original paper.

Steam Power Plant Department

AT one time the steam power plant of the steel industry was considered of minor importance. Steel was the main product to be manufactured and economy in the power plant was hardly deemed worthy of study. Within the past few years a decided change has, however, taken place, and the steam power plant is being placed on a more economical basis.

The review of this phase of the industry shows that the latest installations show a tendency toward higher efficiency in the utilization of fuel, utilization of waste heat and waste combustibles, the application of labor-saving devices and a tendency toward more rugged design of machinery and apparatus to insure continuity of service and decrease the cost of repairs.



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McKeesport Tin Plate Company Operates Modern Steam Power Plant

Power House Equipment for Large Tin Plate Plant—Coal Storage and Coal Handling Facilities, Stokers, Superheaters, Ash Handling Machinery, Feed Water Treatement.

THE McKeesport Tin Plate Company's plant, which by the way, is the largest single tinplate plant in the United States, is located on the Youghiogheny River about 1½ miles above its junction with the Monongahela River and opposite the city of McKeesport, Pa. This plant has always received its coal by river craft. The space available for the boiler house was limited and space had to be had for storage of coal on account of the transportation of coal by water being interrupted during part of the winter months. Therefore the undertaking not only involved the construction of the boiler house with its equipment but also a coal storage basin and wharfage. The provisions for wharfage consisted of a concrete wall built on the harbor line; the wall is about 34 feet high, 19 inches wide at the base, and setting on wooden piles. Along the top of this wall over that portion where coal is unloaded, a railroad track is provided for a locomotive crane. The coal is lifted from the barges with a clamshell bucket by this locomotive crane and deposited in a basin lying between the dock wall and a wall built parallel to the dock wall about 85 feet inshore. The space between these two walls is open, the bottom consisting of a concrete mat placed below normal river level and the space is used for the storage of coal, the coal being deposited in the basin by the locomotive crane before mentioned. There is also a provision made through the construction of a track running along the center of this basin supported on a concrete structure so arranged that there is a tunnel directly under this track communicating with the outside by means of a slot running the whole length of the tunnel and lying between the rails of the track before mentioned, said track construction being supported on the tunnel walls. The track is provided in order to permit of the use of a traveling crusher equipment discharging coal crushed to the required degree of fineness through the slot on to a belt conveyor running the length of the tunnel and discharging into a bucket elevator by which the coal is elevated to the top of the boiler house and distributed into the overhead bunker by means of a suitable belt conveyor arrangement and shuttle. The slot before mentioned through which the coal is discharged as it leaves the crusher, is provided with gates which are only open at the position where the crusher car stands, the open gates forming a hopper guiding the coal into the slot.

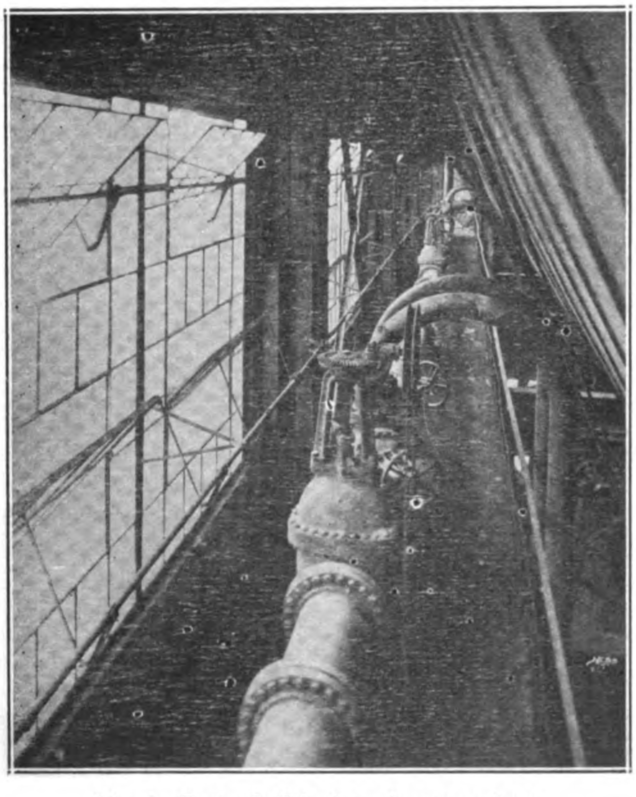

Fig. 1—Part of 18-inch main steam loop.

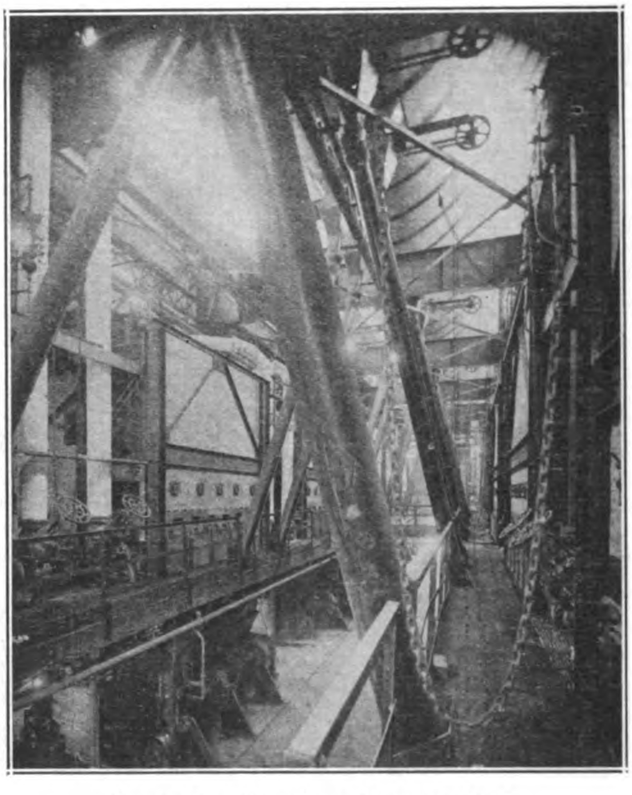

Fig. 2—Interior view of power plant.

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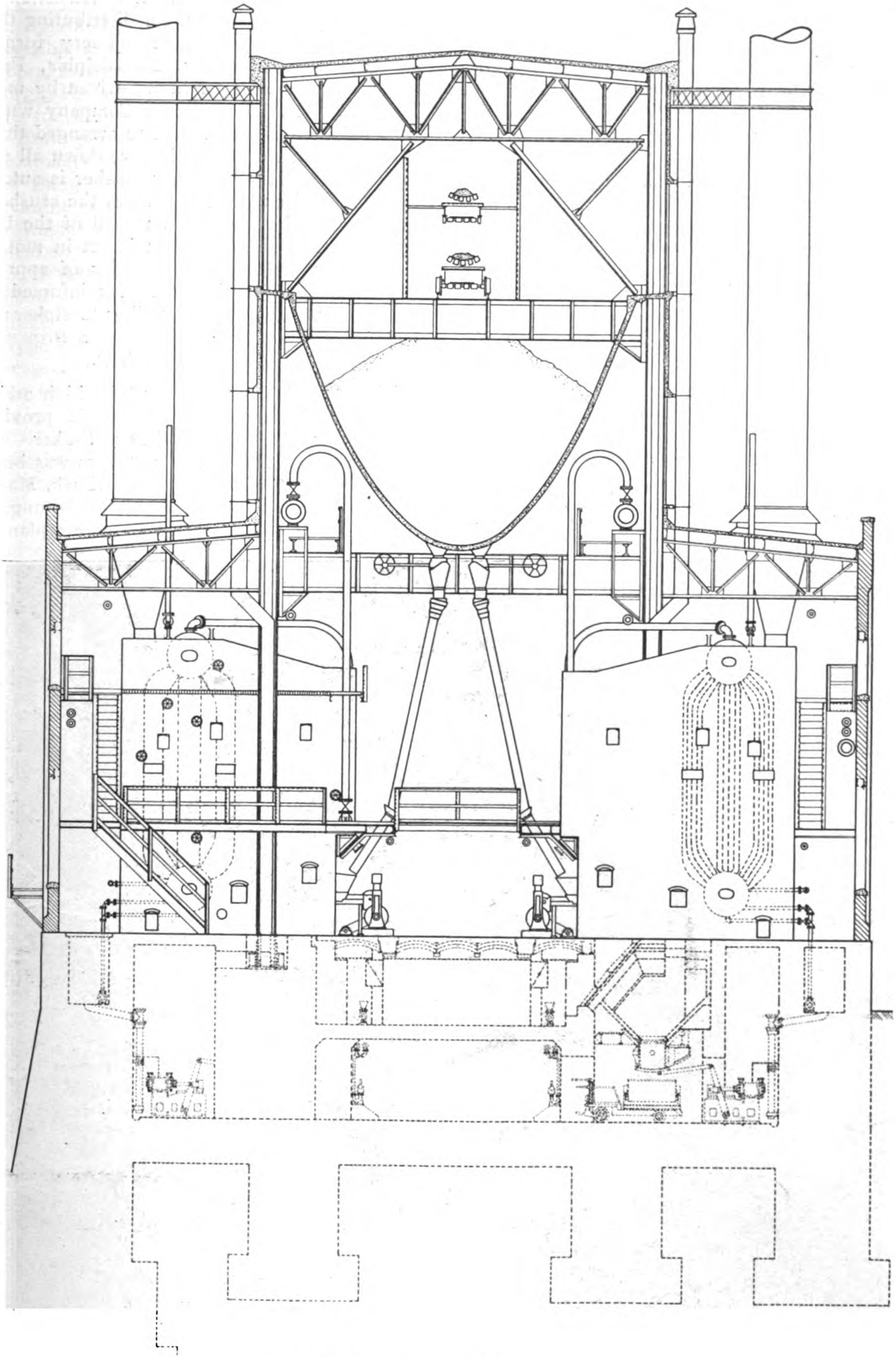

Fig. 3—Elevation of McKeesport power plant.

The crusher car with the crusher equipment, feed belt and hopper were furnished by the Bartlett-Snow Company, Cleveland, O.; the crusher is of the four roll type; the car is provided with standard railway type motors; the Simplex contact system is used instead of trolley wires or third rail; this electrical transmission system was furnished by the Simplex Construction Company of Harrisburg, Pa. The purpose of this arrangement is that the hopper into which the coal is to be discharged as it is lifted from the barges by the locomotive crane before mentioned can always be in the right position to receive the coal without requiring the locomotive crane to make any extra movements to reach its point of discharge and, also to avoid the loss of time and annoyance in shifting of sewer craft. It might be mentioned that the McKeesport Tin Plate Company had between 50,000 and 60,000 tons of coal stored in this coal pocket and on the wharf prior to the coal strike.

Under ordinary conditions, however, it is not expected to store over 15,000 tons of coal in the coal pocket, wharfage space and overhead bunker combined.

Regarding the coal handling machinery this consists of the conveyor in the tunnel, the before mentioned bucket elevator, stationary belt conveyor running half the length of the overhead bunker and shuttle conveyor traveling on a track construction provided for it on top of the bunker for distributing the coal in the bunker. All of this machinery furnished by the Link Belt Company, Philadelphia, Pa.; has a capacity of 120 tons per hour; driven by motors furnished by the Allis-Chalmers Company with Cutler-Hammer interlocking control so arranged that in case any portion of the device is shut down all other coal handling apparatus including crusher is automatically stopped. And on the other hand, the crusher and its feeder cannot be operated until all of the balance of the coal handling mechanism is set in motion. The coal bunker which has a capacity of approximately 5,000 tons of coal; is built of reinforced concrete. The bunker, gates, spouts leading to stokers and construction work were installed by the Brown Hoisting Machinery Company, Cleveland, O.

There are 12,606 hp water tube high arch vertical type Ladd boilers. Each boiler is provided with an eight retort Sanford-Riley Stoker. The air equipment provided with the stokers was built by the B. F. Sturtevant Company, Hyde Park, Mass., which has also provided the turbines for driving the fans. The air is lead to the stokers through a planum cham-

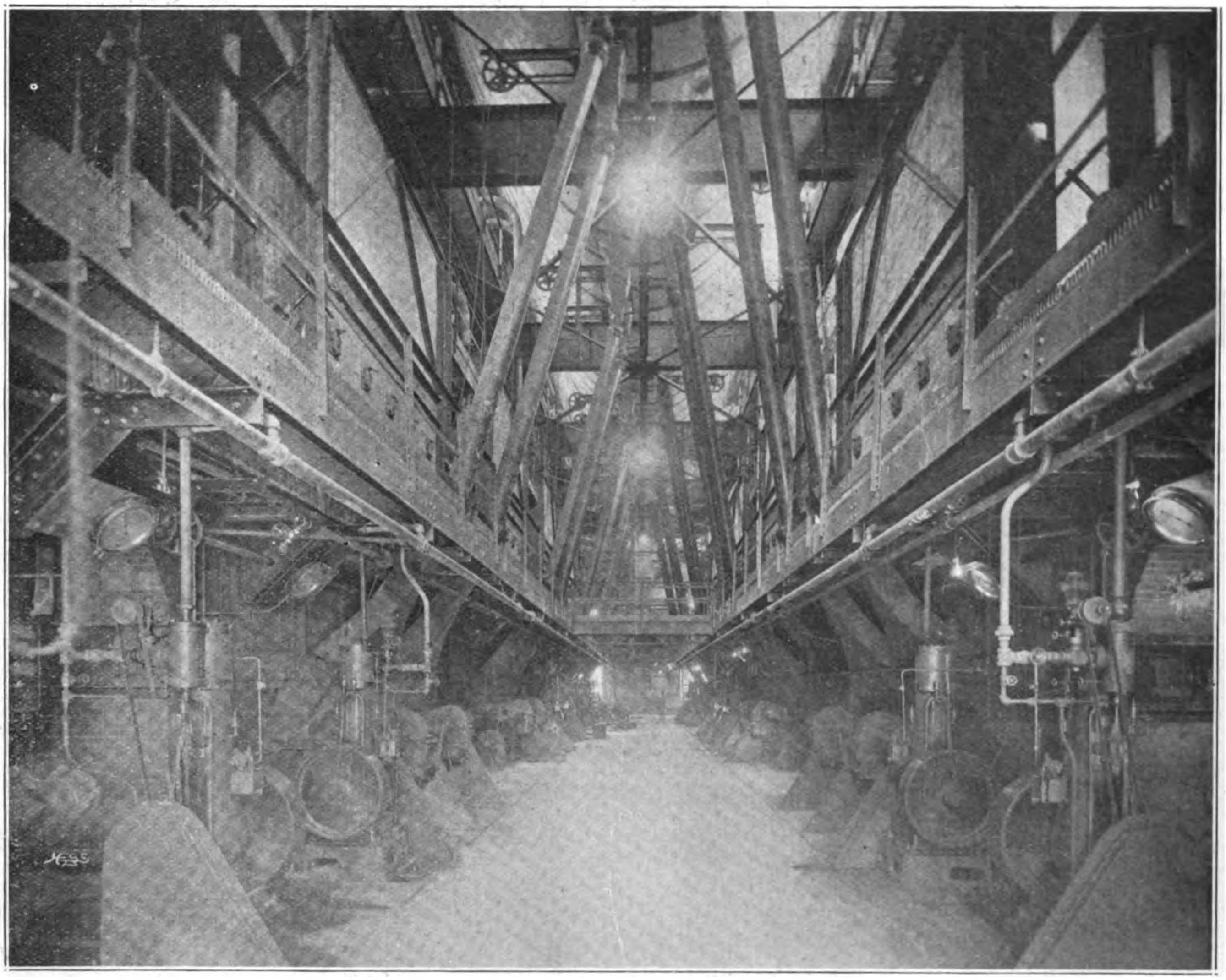

Fig. 4—Interior of power house showing the boilers, general arrangement and method of feeding the coal from the bunkers to the boilers.

ber communicating with each stoker through a suitable wind gate arrangement set opposite center of each boiler in the planum chamber wall. The planum chamber is accessible at all times through an arrangement of lock doors, furnished by Sterrit-Thomas Company, of Pittsburgh, Pa., which is also the case in the provision made for access to wind chambers under the stokers. Both planum chamber and compartments under the stokers are provided with electric lighting so that anything that has to be done in this part of the plant can be done under as favorable conditions as possible. Ample space is provided in the wind chamber compartment so that inspection of stokers and repairs required on stokers as well as disposal of siftings can be conveniently accomplished at any time.

The stokers are driven individually, each by an enclosed type engine built by the E. H. Wachs Company, Chicago, Ill. Stokers are arranged so that two stokers can be driven by the same engine in case of breakdown. The stacks are supported on heavy structural steel bracing forming part of the boiler setting and are braced against wind by a series of struts combined with the building structural steel framework. The stacks are 6 feet in diameter and 150 feet in height measured from the base up and were furnished and erected by the R. Munro & Sons Co., of Pittsburgh, Pa. The stack dampers are carefully balanced with due provision for expansion and are operated by means of control apparatus. Said control is interlocked with a control for governing the speed of the stoker engines and controlling the wind gates, each boiler being provided with its own individual equipment and all control apparatus furnished by the Hagan Corporation, Pittsburgh, Pa.

Beneath the planum chamber there is a sub-cellar provided for the accommodation of the ash buggies. These consist of side dump ash buggies provided with storage batteries and necessary electrical equipment. They were furnished by the Baker-Rausch-Lang Company, Cleveland, O., and are capable of making a turn inside of a 9 inch radius. These buggies convey the ashes from the ash hoppers provided under the boilers to a Bartlett-Snow automatic ash skip hoist arranged at the end of the building. The skip hoist discharges into a reinforced concrete bin somewhat of the same construction as the coal bunker and located on the same level with the coal bunker. This bin is provided with chutes and gates so located and arranged that the ashes can be loaded either into railroad cars or motor trucks. The ash bin and its equipment was furnished by the Brown Hoisting Machinery Company. Regarding the ash hoppers, this part of the equipment is built on cast iron supporting plates throughout, lined with firebrick, provided with suitable spray pipes; the cast iron construction being combined with heavy cast iron neck pieces. These in turn supporting runners for curved ash gates operated by low pressure hydraulic cylinders, the ash gates having sufficient extension beyond the necks so that, when filled with water, a reliable seal is formed against the passage of air into the ash bin. This work was furnished by the Gillespie Manufacturing Company of Pittsburgh.

Youghiogheny River water is used, treated by the Cochran-Sorge system delivered to the boilers by means of Epping-Carpenter compound direct acting pot valve type feed pumps. The feed pumps and the water treating system being located in a separate building and provision made there for the storage of chemicals. The water treating system was furnished by the Dravo-Doyle Company, Pittsburgh, Pa.

The boilers are equipped with Foster superheaters furnished by the Power Specialty Company, New York, N. Y., designed for delivering the steam at 125 degrees superheat. The boilers are designed for 200 pounds pressure per square inch. The Republic steam flow meter is used, each boiler being provided with an individual steam flow meter also a totalizing flow meter on the main steam line. All of the steam piping both for high and low pressure, also all feed water, blow-off, and service water piping was furnished by the Crane Company of Chicago, Ill., the contract for this work including the erection was placed with the B. Floersheim Company, Pittsburgh, Pa.

All masonry work including dock walls, the submarine work in conjunction therewith, coal pocket, boiler house, heater and water treatment building foundations,

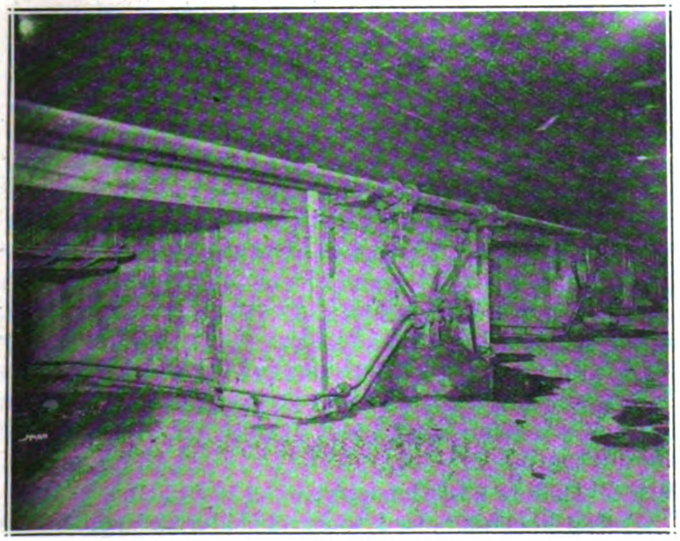

Fig. 5—Piping for operating ash hoppers in connection with 24 Wood's valves.

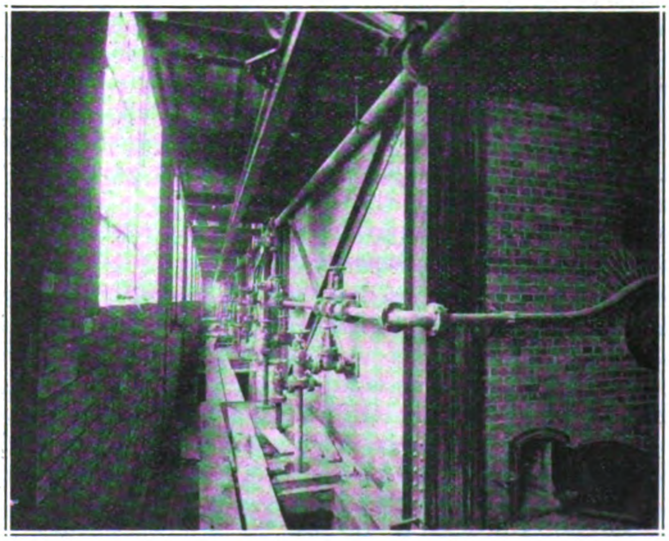

Fig. 6—Blowoff for six boilers, auxiliary feed header, also connections from main feed header.

and in fact all foundation work of any character or description, was furnished by the E. M. Wichert Company, Pittsburgh, Pa. Structural steel work entering into the building construction of boiler house and heater house was furnished by the Fort Pitt Bridge Company, Canonsburg, Pa., the general contractor for the buildings was the Lawrence Steel Construction Company, Canonsburg, Pa.; the general contractor for ways were furnished by the Taylor & Dean Co., Pittsburgh, Pa. Pipe covering, 85 per cent magnesia, furnished by Keasby & Mattison, Pittsburgh, Pa. Fenestra metal sash was furnished by E. F. Hauserman Company, Cleveland, O. The coal bunker arrangement with its relationship to the building construction work and window openings is such that daylight is reflected to the boiler house floor. The best of ventilation is provided both above the coal bunker and for the space below. The space above the bunker is sealed off from the lower part of the building in order to avoid any coal dust from sifting down into the boiler house. Ventilating flues are provided alongside of the building columns and extending above the roof of the building so that the ash tunnel receives thorough ventilation. The buildings are brick clad up to the leanto roofs and above that point are covered with metal lath and cement. The roofs are of concrete and water proofed with composition roofing.

The boiler house floor level is about 8 feet above yard level. This has been decided on owing to extreme high flood level being above the yard level of the plant. The foundation work is all water proofed and pumps are provided for taking care of accumulation of water arising from the drainage from the ash pits during floods.

S. Diescher & Sons had complete charge of the engineering work of this plant and all apparatus not standard has been designed by that company.

Review of Steam Power Plant Improvement

Boiler Sizes and Pressures Increased — Superheaters and Economizers—Blast Furnace Gas and Coke Breeze as Boiler Fuel. Boiler Settings, Waste Heat Boilers, Feed Water Treatment.

By F. E. KLING.

A DECIDED change has taken place during the last few years in the steam and power departments of steel plants. This part of the iron and steel industry used to be considered of minor importance as it did not directly produce iron or steel and was, therefore, not given as much attention from a standpoint of improvement as the iron and steel producing departments. However the increased cost of fuel, the high cost of labor, the growing scarcity of common labor and the necessity of decreasing the cost of production to compete in the world markets has made it necessary to also pay more attention to the production of steam and power.

We find, therefore, in the latest installations and improvements a tendency towards higher efficiency in the utilization of the fuel, utilization of waste heat and waste combustibles, the application of labor saving devices and a tendency towards more rugged design of machinery and apparatus to insure continuity of service and decrease the cost of repairs. The outstanding points of improvements are as follows:

Steam Pressure and Superheat.

The steam pressure has been increased from the usual standard of 125 to 150 pounds to a new standard of 200 to 250 pounds with a tendency to go even higher, keeping in step with the central power stations, one of which (Joliet, Ill.) has gone to 350 pounds pressure and has been in operation for some time. Several other power stations now under construction will have 350 pounds boiler pressure.

Superheating of steam has been introduced into steel plants with the power plant installations of recent years. The advantages of superheated steam, no condensations in steam lines, decreased condensation in prime movers, etc., and therefore lower steam consumption, are well established and pay for the additional care superheated steam requires. However the degree of superheat should not be carried too far or the trouble might overbalance the advantages. With ordinary engines, not built for superheated steam, it is not advisable to go higher than 60 to 75 degrees F. while 100 to 125 degrees or a total temperature of about 490 degrees F. can be used in engines designed for these conditions, provided proper cylinder lubrication is used. In connection with turbines the degree of superheat is limited by the strength of materials. The highest degree of superheat used, on a large scale, is at the Buffalo General Electric Company. It is 275 degrees F. at a pressure of 275 pounds or a total temperature of 689.4 degrees F. The tendency, however, is not to go to such high temperatures but to make up for this deficiency by higher pressures, as the above temperature is too close to the safe limit of 700 degrees F.; the temperature not being so well under control as the pressure.

At the present stage of development 150 degrees superheat and 250 pounds pressure are safe and, therefore, well adapted for steel plants. This is for use in turbines. Small turbines for driving auxiliaries are standardized for 250 pounds pressures. Also the A. S. M. E. pipe flanges and fittings are standard for this pressure.

Size of Boilers and Capacity.

A 500 hp boiler used to be considered large. The latest installations have boilers of 1,000 to 1,500 hp and four boilers of 2,650 hp each are now under con-

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struction for the Ford blast furnaces in Detroit. The advantages of the large boilers over the smaller ones are; lower first cost, lower cost of operation and repairs, higher efficiency, less ground space required, less piping and fewer valves and other apparatus.

The maximum output of modern boilers equipped with mechanical stokers is 300 to 400 per cent of rating. Although this is not economical and boilers should ordinarily not be operated above 200 per cent, it is required at times in emergency.

Gas fired boilers have also been developed for higher rating. One hundred and fifty per cent is a high rating with the ordinary boiler with natural draft. With induced draft the gases moving through the boiler at a higher velocity, it is possible to obtain over 200 per cent.

A remarkable boiler installation was put into operation at the Duquesne works, Carnegie Steel Company, in the latter part of 1918, it consists of 5 B. & W. type boilers of special design for blast furnace gas, with induced draft fans. They are 1,290 hp each, carry 250 pounds pressure and 150 degrees F. superheat. An average efficiency of 73 per cent has been obtained at an average rating of 150 per cent, maximum rating obtained was 217 per cent.

Economizers.

When going to higher steam pressure the temperatures of the waste gases from the boiler also increased and, therefore, offsets some of the advantages of the higher pressure by the decreased efficiency of the boiler, unless economizers are installed.

The greatest drawback to economizers has been the trouble from corrosion and the consequent high cost of repairs. This can, however, be eliminated by preheating the feed water to a temperature somewhat above the dew point of the gases, to prevent the condensation of the moisture in gases on the outside of pipes. By doing this and installing large combustion chambers, another trouble, the forming of scale or a sticky soot on the gas side of the pipes is eliminated and therefore the scrapers, which are very expensive in upkeep can be replaced by soot blowers, also if the temperature of the water is high enough, the pitting of the inside of the tubes is eliminated. There are usually sources of heat in steel plants to preheat the feed water prior to entering economizer or else hot water is available (cooling water from furnaces, gas engines, etc.).

The overall efficiency of a modern boiler with economizers is 80 to 85 per cent, which is 33 1/3 to 41.7 per cent more than is obtained with the usual boiler having an efficiency of only 60 per cent and which is worth considering. The Republic Iron & Steel Co., has installed and put into operation at Youngstown in the summer of 1919 economizers in connection with four 1,130 hp boilers, which is probably the largest installation of economizers in a steel plant in this country. The water enters the economizer at about 180 degrees F. No trouble has been experienced.

Boiler Setting.

More attention is being given to the boiler settings than heretofore. The importance of a tight setting is well known, for every pound of infiltrated air has to be heated to the temperature of the escaping gases and is therefore a loss of heat. All kinds of plastic coatings have been tried with more or less success, which is the best that can be done with an old boiler. New boilers should have steel plate jackets covering the entire setting. If the jacket is made of ¼ inch plates, ⅝ inch rivets, not more than 2½ inch spacing, the plates are properly stiffened by structural sections, the door frames are riveted on tightly, the doors and frames being machined and clamped together, we not only have a tight, but also a very strong setting, which prevents the walls from bulging out. All stiffening and supporting members should be on the outside of the plate, away from the heat.

Insulating the setting with insulating powder or brick has been applied to new installations, which is a step in the right direction, as it decreases the loss of heat.

Water Softening.

A large feed water softening plant has been put into service in the summer of 1919 at the Republic Iron and Steel Company, Youngstown, O., and is described in The Blast Furnace and Steel Plant, August, 1919. When water contains 11 grains of incrusting solids per gallon as is the case with Mahoning river water in Youngstown, a water softening plant is necessary and will pay for itself in a few years in decreased boiler repairs, cleaning costs and increased boiler efficiency. Also the cost of a water softening plant is partly made up by the lesser cost of the boiler installation, as fewer boilers are required, because fewer boilers are off for repairs and cleaning.

Blast Furnace Gas as Boiler Fuel.

The surplus gas from blast furnaces can be utilzied best as a fuel for boilers. If this is done most economically, sufficient steam and power can be generated with same so that with the addition of steam from open hearth waste heat boilers the entire steel plant, including finishing departments, can be operated, using coal only in emergency.

To obtain this economy the gas must be cleaned well and burned efficiently. The best method of cleaning gas for use under boilers is the dry method, which has been developed during the last few years. The first large installation of this kind, cleaning all of the gas from a 550-ton furnace was put into operation in January, 1919, at the Ohio Works, Carnegie Steel Company, Youngstown, O., and which is described in The Blast Furnace and Steel Plant, April, 1919. Cleaners of this type (Kling-Weidlein) are now under construction for eight furnaces. The advantages of dry cleaned gas for boilers are as follows:

1. The sensible heat of the gas is retained, which results in better combustion, higher flame temperature and higher efficiency. The sensible heat saving amounts to from 7 to 10 per cent of the total heat in the gas leaving the furnace.

2. What little dust remains in the gas from the dry cleaner is so fine that 95 per cent of it goes through a 200 mesh sieve, is carried in suspension by the gas and escapes with same, it therefore does not deposit in the boiler setting. The action of this dust on the boiler tubes is quite different from that of wet cleaned gas. The latter bakes to the tubes of boiler and superheater and is hard to remove while the former just

adheres to them and is easily removed with a steam lance or soot blower. The accumulation of the dust from the dry cleaned gas on the tubes is so slow that the efficiency of the boiler does not drop appreciably in a week. A test run on a boiler for three weeks without blowing the tubes showed a drop in efficiency from 70 per cent to only 66 per cent. On a similar test, using semi-washed gas, the efficiency dropped from 70 per cent to 40 per cent in three weeks.

3. No accumulation of sludge in gas mains and no sludge and water dripping from gas burners.

4. Dry cleaned gas makes the use of an economizer or air heater possible, due to the lesser trouble from dust collecting on the tubes and the ease of removing same with a soot blower and therefore paves the way to 85 per cent or even higher combined boiler and economizer efficiency, depending on the amount of heating surface of the economizer or air heater or both.

5. If an economizer or air heater, or both are used, it is possible to reduce the stack temperature to 300 degrees F. or lower, so that even some of the sensible heat of the moisture is recovered, the blast furnace gas entering the boiler at a temperature of 350 degrees F. or higher.

Gas Burners.

Remarkable improvements have been made in gas burners during recent years. The most notable burners in use now are the Terbeck, Bradshaw and the Kling-Weidlein. The principles striven for in these burners are the thorough mixture of gas and air and the aspirating effect, allowing the gas to aspirate the proper proportion of air at different gas pressures. Tests of the Kling-Weidlein burner show a correct proportioning between pressures of two inches and seven inches water. Complete combustion takes place within four feet from the burner, resulting in low stack temperature and therefore high efficiency, also the excess air is low and the combustion temperature therefore high, which means higher rating and efficiency.

Forty-eight boilers at the Ohio Works, Carnegie Steel Company, have been equipped with these burners. Without making any other changes it was found that 10 to 15 per cent more steam was generated than with the old gooseneck burners. The stack temperature was decreased from 900 degrees F. to 600 degrees F. because the combustion was completed before the gases came in contact with the boiler tubes. Pulsation in the combustion chamber and setting and the consequent leakage of gas have been eliminated.

Open Hearth Waste Heat Boilers.

Boilers have been installed in connection with open hearth furnaces in a great many plants. Most of these boilers are working satisfactorily. If these boilers are installed properly, are equipped with reliable auxiliaries, are provided with airtight steel jackets and valves to prevent infiltration of air, and proper attention is given to operation, they are a good investment.

Coke Breeze.

Coke breeze, which usually has a heating value of 10,000 to 12,000 Btu per pound and which was formerly sent to the dump is now being used under boilers. If the coke breeze is of a size to pass through a ⅝ inch screen with at least 20 per cent dust it can be burned successfully on forced draft chain grates; if larger it can be burned on hand fired grates or on underfeed stokers by mixing with coal.

Prime Movers for Power Generation.

The tendency towards large units is here also noticeable. Turbo-generators of 7,500 to 20,000 kw capacity seem to be the most favored sizes.

The efficiency of turbo-generators above 10,000 kw compares favorably with that of the largest units in central stations.

A 15,000 kw turbine has been in operation at the Duquesne Works, Carnegie Steel Company in connection with the boilers above referred to. A 15,000 kw unit is in course of fabrication to be installed at the Homestead Works, Carnegie Steel Company (Carrie Furnace). At the Ford furnaces 20,000 kw units will be installed.

These large units, working with high pressure steam, high degree superheat and good vacuum and being supplied by high efficiency boilers do not lag much behind the gas engine in thermal efficiency, but are ahead of same from a monetary standpoint, as the cost of installation, operation and repairs is considerably less. Also the turbines have the advantage of being more reliable, require less floor space, are better able to take care of peak loads and the efficiency is uniform throughout a large range of load.

Miscellaneous Prime Movers.

Although not bearing directly on the main subject, the following developments of recent years are closely related to the steam power problems of steel plants.

Uniflow Engines.

This type of engine is well adapted for rolling mill drives. The steam consumption is less than that of a compound engine for loads varying over a large range. They also respond more quickly to peak loads and are simpler and smaller than compound engines. Two engines have been working very satisfactorily for two years at the Youngstown Sheet & Tube Co., one 44x50 inches driving a 12-inch bar mill, and one 37x48 inches on a 9-inch rod mill. The steam consumption is approximately 13 pounds per brake hp hr.

Reversing Engines.

Several single lever control reversing engines driving blooming mills have been in operation for some time. A test on a 46x76x60 inch engine of this type at the Youngstown Sheet & Tube Co., showed a steam consumption of about 21 pounds per indicated hp hr, which is remarkable for this kind of service, the older types of engines requiring 27 to 35 pounds.

Blowing Engines.

Three high speed blowing engines are in operation at the McKinney Steel Company, Cleveland, O., having 34, 66 and 84 inch cylinders and 48 inch stroke, and a capacity of 45,000 cubic feet air per minute at 75 rpm. The remarkable feature of these engines is the short stroke, which renders the engine very compact. Also the steam pressure is very high for a reciprocating engine being 225 pounds and 500 degrees F. temperature. The exhaust steam is used in low pressure turbo-generators. Steam consumption of combined engine and low pressure turbo-generators is 11.5 pounds per brake hp hr.

Future Steam Power Plant Development

Sees the Steam Units as the Most Important Future Source of Power for Blast Furnace Blowing—Emphasizes the Advantages in the Use of Economizers in Boiler Installations.

By **BRYANT BANNISTER.**

THE steel industry stands paramount in this country as a consumer of power. All branches of the industry, large and small, from the mining of ore to the fabrication of the product, require power in one or more of its various forms. It will thus be appreciated that with the increasing fuel and labor costs and the general awakening to the necessity for greater conservation of our natural fuel resources the steel industry will make more and more effort to improve the prevailing condition of its complex power systems.

The electrical end of the steel mill power system does not differ materially from the modern central station of similar size. The design of electrical generating apparatus determines its economy which is influenced only slightly by its coördination with the balance of the plant, and, furthermore, the generating station as a whole has been so thoroughly standardized by public service companies that there is little need for a discussion of this part of the system.

The generation of steam, however, presents an entirely different problem on account of the large amount of by-product heat usually available. Most of this heat is in the form of blast furnace gas and may be used either for the production of steam or for the operation of gas engines.

The improvement during recent years in both steam generating and steam consuming equipment has been so tremendous that today a well designed and equipped station burning blast furnace gas under high pressure boilers, can be made to produce power more economically than is possible with the gas engine. This fact indicates that future installations will consist of steam units rather than gas engines, for blast furnace blowing as well as for general power. The economical generation of steam, therefore, becomes the most important problem in connection with steel mill power systems. It is of course essential that as much steam as possible be generated from by-product heat, but irregularities in furnace operation produce irregularities in gas supply not corresponding with variations in the demand for steam, making necessary the combustion of solid fuel, usually coal, which introduces the problem of best arrangement for such combustion.

In the interest of first cost it is desirable to provide for the burning of either blast furnace gas or coal under certain boilers. A saving represented by the cost of extra boilers, buildings, fans, and piping is in this way effected without a sacrifice in economy by providing a gas combustion chamber which is complete and separate from the stoker fired furnace, but delivering its gases to the boiler at the same place. It is, therefore, obvious that so far as the boiler is concerned it is immaterial from which combustion chamber the products come.

The horizontal type water tube boiler can be provided with a furnace containing the necessary elements for the most economical combustion of both coal and gas. Designs have been developed incorporating this principle. Previous attempts to combine the combustion of coal and gas have been unsuccessful because both were introduced into the same chamber in spite of the fact that the combustion requirements differ radically.

Blast furnace gas contains a high percentage of nitrogen which renders the products of combustion bulky for the quantity of heat evolved. This must be taken into account in proportioning the boiler and its gas passages, as will be apparent when it is considered that under good operating conditions 45 pounds of combustion products are required per Bhp hour produced from coal, whereas this figure increases to 70 pounds for blast furnace gas, an increase of 56 per cent. These figures show that a drop in flue gas temperature represents 56 per cent more heat recovered from blast furnace gas than from coal, emphasizing the importance of so proportioning the gas passages that low exit temperatures will result.

High steam pressures are demanded by modern turbine equipment and low exit temperatures are impossible from boilers carrying high steam pressure. It is therefore logical to introduce the economizer as an element of the steam plant.

The transfer of heat from the products of combustion of water depends directly upon the temperature differential showing that it is economical to make the economizer, which contains water at a temperature lower than that of the boiler, as large as possible, the limiting factors being the inlet and outlet water temperatures. The inlet temperature of necessity must be above the dew point of the gases—150 degrees F. being a safe temperature except perhaps for abnormal conditions, and the exit water can safely approach within 60 degrees of the saturated steam temperature. Local conditions, such as the normal and maximum rate of steam production from the unit, will determine the exact size relationship between economizer and boiler when blast furnace gas is being burned. The heating surfaces and gas passages will be more ample than would ordinarily be provided for a coal fired installation, with the result that unusually good heat absorption will be secured when coal is being burned for the same rate of steam production.

The coördination of a horizontal water tube boiler having 22 foot tubes arranged 14 deep and an economizer having about 70 per cent as much heating surface as the boiler, makes a very economical unit. Such a unit carrying high steam pressure and operated at 200 per cent of the boilers' rated capacity with good combustion, will show an efficiency better than 81 per cent, the economizer doing 16 per cent of the work. A straight boiler having the same width and tube length but arranged 24 tubes deep, would contain about the same heating surface as the 14 high boiler and economizer combined, but would show only about 75 per cent efficiency at the same rate of steam production. The difference in economy is so much in favor of the boiler-economizer combination that there is little argument for the straight boiler especially with the present and probable future fuel values.

It is a further argument for economizers that the decrease in efficiency for a considerable increase in the rate of steam production is very small. This fact is of great importance in the design of the plant because it permits high rates of steam generation with good economy, with the result that the rated capacity can be kept a minimum both for normal operation and for spare equipment.

This brings us to a consideration of details which must harmonize with the boiler equipment if good over-all results are to be secured. Perhaps the most important of these details is the selection of fan equipment. On account of the high draft loss through boilers burning blast furnace gas, induced draft is necessary. The fan should be capable of handling the maximum quantity of gas required to operate the boilers at the highest ratings that emergencies might require, making due allowance for air infiltration. In many instances the induced draft fan limits the maximum rate of steam production because of excessive air for combustion and air infiltration, which alter the conditions for which the fan was designed. The fan equipment represents a small part of the total plant cost, and since the maximum steam production may be limited by the fan it is apparent that liberal capacity should be provided. Forced draft fans for gas burners and stokers should be provided with a like margin of capacity.

The advantage of intensive steam production has been shown, but without good feed water such operation is not only difficult but sometimes dangerous. A clean boiler tube has almost unlimited capacity for transmitting heat, but a comparatively thin layer of scale retards heat flow to such an extent that overheating and rupture may occur. Overheating of tubes is the cause of most tube failures. The failure of a tube forces the shutdown of a boiler regardless of its size and the importance of good feed water therefore increases with the size of boiler units. With good water, tube failures are almost unknown making a boiler one of the most reliable elements of the entire plant. It is thus possible to secure the advantage of large boiler units without sacrifice of reliability.

Large boiler units, because of width, require the use of mechanical soot blowers. These blowers, if properly placed and judiciously operated, will maintain commercially clean tubes, even when dry cleaned blast furnace gas is burned. This makes possible the utilization of sensible heat in the gas which is lost when the gas is passed through primary washers to remove dust content.

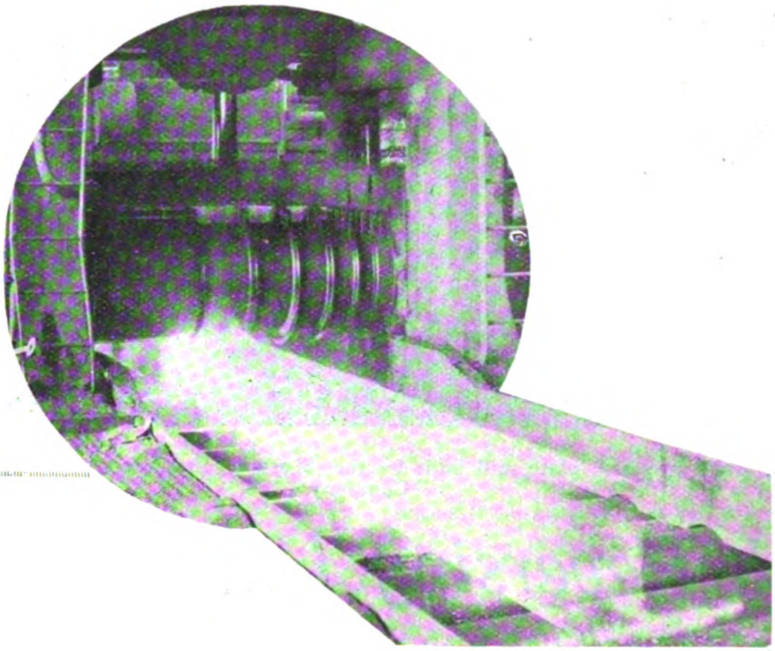
It would be quite unwise to close this discussion without a few words on the subject of brick work around a boiler. The many forms of special refractory material on the market is good evidence that engineers appreciate the importance of this detail. Only general advice can be given without full knowledge of local conditions, but some very general rules are surely in order. All walls subjected to high temperatures on one side only will tend to elongate on the hot side forcing the wall inwards towards the source of heat unless provision is made to prevent it. Bonding tile with flexible connections to outside steel work aid materially in preventing this action, but probably the best provision is to arch the wall slightly away from the source of heat so that the wall will straighten when expansion takes place. It is often possible to incline walls away from the vertical so that a portion of the weight can be carried outside the furnace. This construction applies especially to furnace fronts over stokers, gas burners, etc. Abrupt breaks in surface, such as shelves, only serve as clinker supports and should be avoided. It is a good rule to make the refractory part of a wall heavy enough to support itself, insulate this against great heat loss, and then shroud it with another self-supporting brick wall, or with a steel casing. In any event provide liberally for movement of the refractory wall without a corresponding movement of the casing by making all bonds flexible. In this way only is an air tight setting possible. It is generally better to provide extra brickwork rather than extra supporting steel. Another generality: Avoid suspended arches whenever possible, making walls vertical or slightly inclined outwards.

In any steel plant the producing departments are served by certain elements which, because of their character, naturally lend themselves to consolidation into a "power system." These elements are as follows:

1. Power station, including boilers, turbo generators, pumps, switchboard equipment, feed water purifying plant, etc.
2. Mill service-water pumps and distributing system.
3. Central coal handling plant and distributing system.
4. Waste heat boilers and steam distributing system.
5. Air compressors and compressed air distributing system.
6. Hydraulic power pumps pipe lines, accumulators and control equipment.
7. Blast furnace blowing equipment.
8. Heating and ventilating equipment.
9. Sub-stations, mill motors, lighting and electric transmission system.

These items are closely related, and the necessary engineering and operating supervision is of a character quite different from that required by other departments of the plant. The fact that these items are common to more than one producing department, with few exceptions, is an added reason for their consolidation.

Rolling Mill Department



THERE is hardly any phase of the steel industry in which more rapid strides are being made than in the rolling mill. There is also hardly any phase of the industry which is more shrouded with mystery as to accurate information. Little has been published concerning such subjects as roll pass design which is of value, and much investigation will be required before rolling mill practice can be placed on a scientific basis.

These facts are the fundamental reasons for the establishment of a bureau of research at the Carnegie Institute of Technology. The director of this bureau has contributed a very interesting article on this department, which indicates the great value which such research may be to the steel industry. The work of this bureau deserves the utmost support of the industry for it is certain that the results which may be expected will be of inestimable benefit. A number of other articles and descriptions of modern installations in this department show the trend of technical developments.

Due to the great demand for sheets a great deal of interest is being evinced in sheet rolling. Investigations for improving this process are numerous, and since so little technical development has taken place it may not be amiss to expect improvements in the sheet mill. In fact it is possible that in spite of the previous sad experience that the continuous process of sheet rolling may again be attempted.

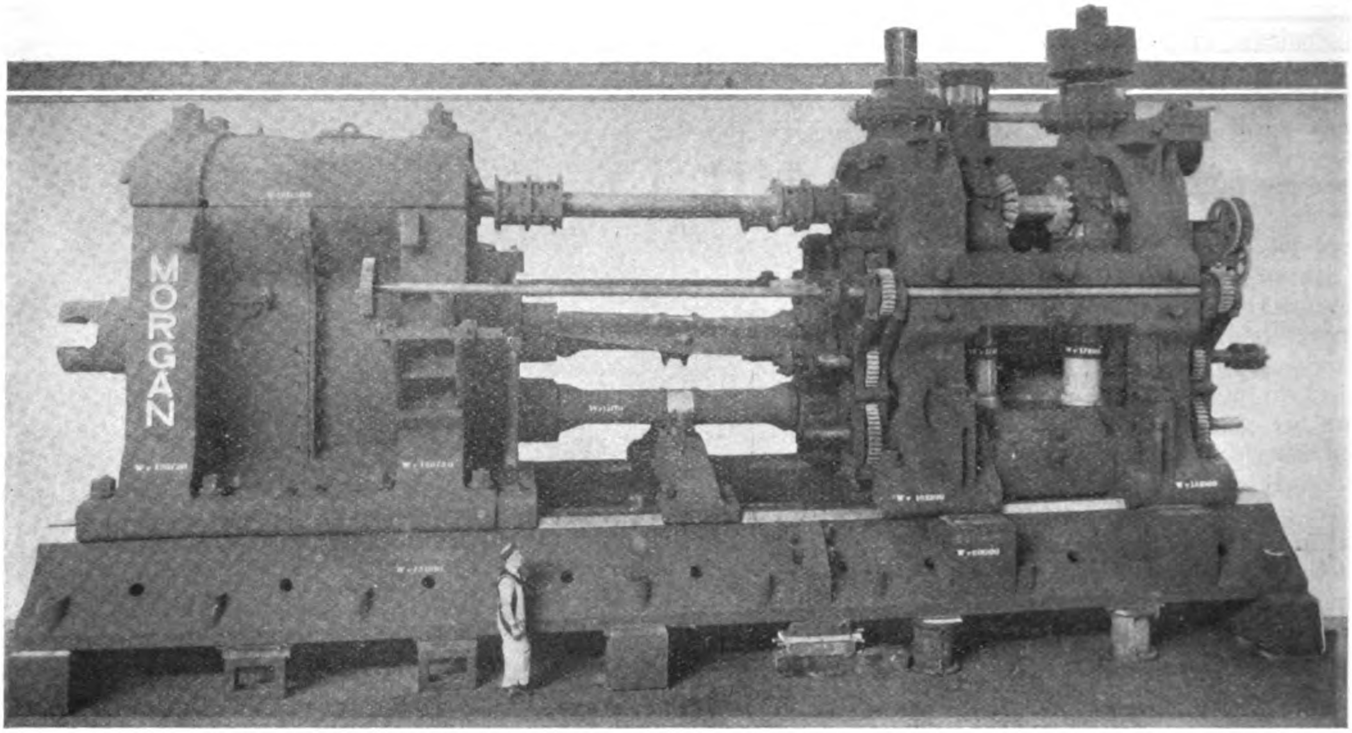


Fig. 1—View of 60-inch two-high universal plate mill built by the Morgan Engineering Company, for the Bethlehem Steel Company.

Two-High Reversing Universal Plate Mill

Morgan Engineering Company Builds Sixty-inch Universal Plate Mill Electrically Driven, for Sparrows Point Plant of the Bethlehem Steel Company.

THE MORGAN ENGINEERING COMPANY of Alliance, O., has recently shipped a 60 inch two-high reversing universal plate mill with mill tables to the Bethlehem Steel Company's Sparrows Point plant. This mill is similar to the 60 inch universal plate mill which was built by the Morgan Engineering Company for the Indiana Steel Company at Gary, Ind., with the exception that the Gary mill was of the three-high type and had other features somewhat different.

The maximum size of slab to be rolled by this mill measures 62 inches wide and 13 inches thick at the large end by 48 inches long and weighs about 10,000 pounds. This slab can be rolled to a plate 60 inches wide by ⅜ inch thick and about 131 feet in length. The mill is also suitable in every respect for rolling sheared plates when the vertical rolls are removed.

The leading driving spindle, connecting with the mill motor, is coupled to the top pinion, thus reducing the stress on the teeth of the main pinion, this being a departure from the usual practice of driving the bottom pinion, wherein the power required to drive the top horizontal roll and all four vertical rolls is transmitted through the teeth of the bottom pinion.

The horizontal rolls are of chilled cast iron 36 inches diameter on the body and 84 inches long between necks. The lift of the top roll is 20 inches. The four vertical rolls are of cast iron, chilled on the barrel which is 21 inches in diameter. The adjustment of the vertical rolls is actuated by means of a train of gearing enclosed in auxiliary housings. This gearing is driven by two 50 hp mill type motors located on brackets attached to the pinion housing.

The screw down is operated by two 80 hp mill type motors located on a pulpit adjacent to the mill.

Two mill tables are furnished, each table consisting of 22 rolls 34 inches long and 16 inches in diameter, spaced at intervals of 27 inches making a total length of 53 feet 3 inches from center line of mill rolls for each table. Each table is driven by a 150 hp mill type motor and is equipped with adjustable centering guides for entering the ingot central with the vertical rolls.

The electrical equipment for driving the main rolls of the 60 inch universal mill is being furnished by the Westinghouse Electric & Manufacturing Co. The reversing dc motor is a double armature unit. Both armatures are mounted on a common shaft, which is supported by two pedestal type bearings. These pedestals are supported by a heavy bed plate. Fig. 3 gives a view of this motor. Each armature is wound for 700 volts and they are so connected with the two generator armatures that the effect of 1,500

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volt operation is obtained. The motor has a maximum peak rating of 17,500 hp. The speed range is from zero to 100 rpm in either direction.

The motor is enclosed and is arranged for forced ventilation. An air washer is being used to clean the ventilating air before it is blown into the motor.

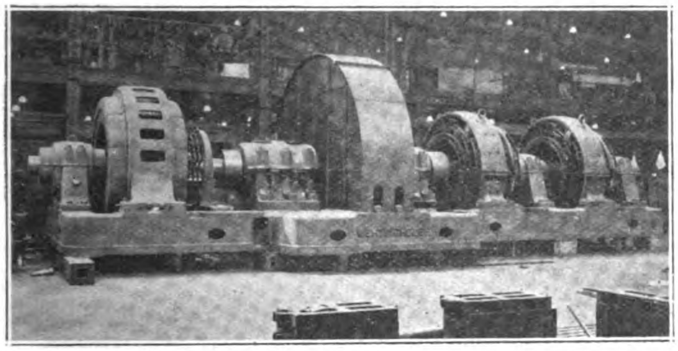
Fig. 2—Flywheel motor-generator set.

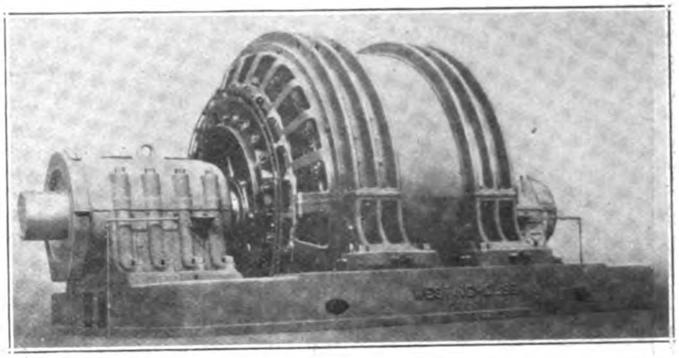
Fig. 3—Main motor for driving mill.

The reversing motor receives its power from two 3,000 kw, 700 volt dc generators operating at 368 rpm. These generators are of the compensated interpole type and are designed to have the same peak capacity as the reversing motor. The generators are driven by a 5,000 hp 6,600 volt, 3 phase, 25 cycle wound rotor induction motor.

In order to equalize the high peaks obtained on the mill and prevent their being reflected back on the power lines and generating station, a 150,000 pound cast steel flywheel is mounted on the motor generator set. The two generators, the ac motor, and the flywheel are mounted on a common bed plate The flywheel is enclosed in a cover to reduce windage losses. Fig. 2 gives a view of the flywheel motor generator set. A small induction motor driven exciter set is used to supply field excitation for the reversing motor and the dc generators.

The primary control for the 5,000 hp motor is arranged so the set can be rapidly brought to rest by simply opening the forward running breaker and closing the reversing breaker. This reverses the power to the motor, causing it to exert a torque in the opposite direction, and thus come to rest quickly.

A liquid slip regulator is used to control the secondary of the 5,000 hp induction motor. This regulator controls the input to the induction motor and limits the peaks drawn from the power lines. This is so connected in the circuit that it automatically inserts resistance in the secondary of the induction motor when the load reaches a predetermined value. This causes the set to slow down, which permits the flywheel to give up part of its stored energy, and thus absorb the peak load.

The reversing motor is controlled by means of a master switch located in the operator's pulpit. The main motor is reversed by reversing the field of the generators and the speed of the reversing motor is practically proportional to the voltage up to full voltage on the generator. From here the speed of the motor is increased to full value by weakening the field. This system makes the control extremely simple and easy of operation.

It is of interest to note that the total weight of this mill, without the tables is 966 tons. When considering the size of an installation like the one described it is of interest also to recall the early experience with reversing drives as pointed out by Wilfred Sykes before the June meeting of the American Iron and Steel Institute:

> The reversing motor has been used for all types of reversing mills and to date has not found its limitations. Blooming mills, billet mills, plate mills and structural mills have all been electrified with success. The first installation put in operation 12 years ago at the South Works of the Illinois Steel Company drove a two-high universal plate mill.

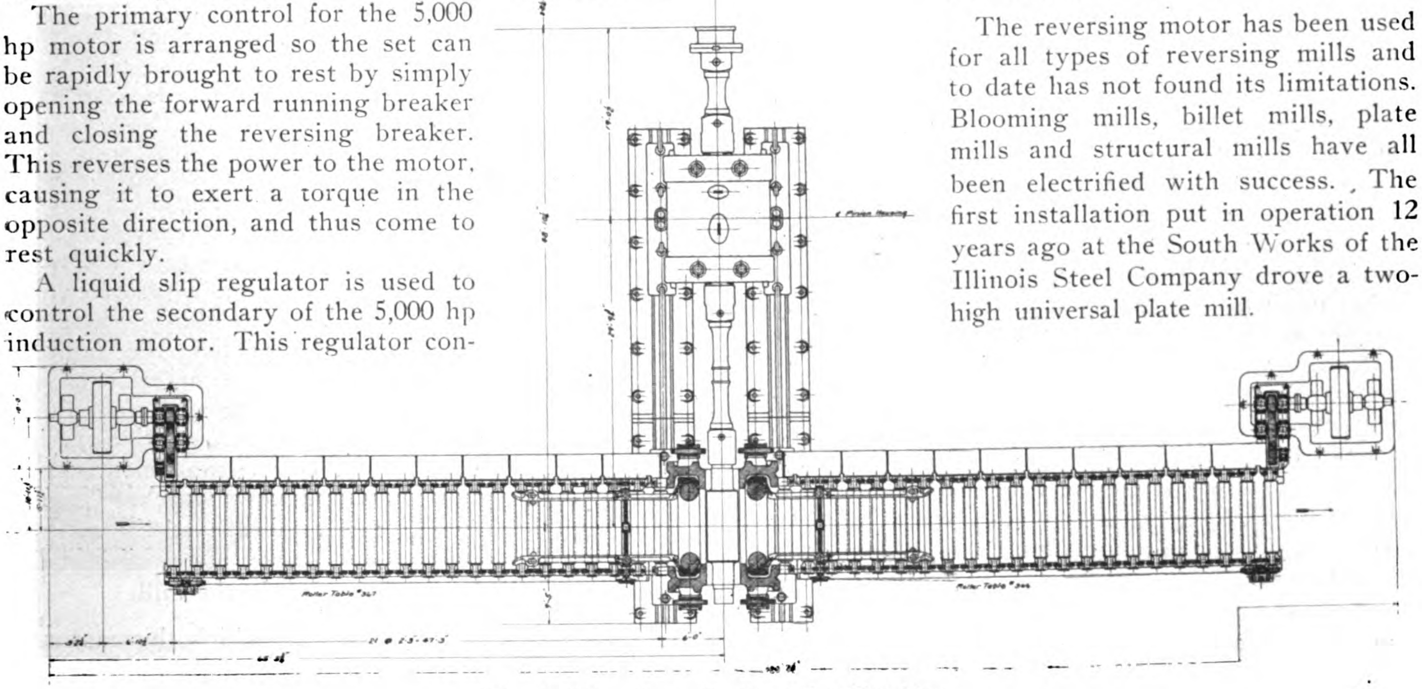

Fig. 4—Plan view of mill and mill tables.

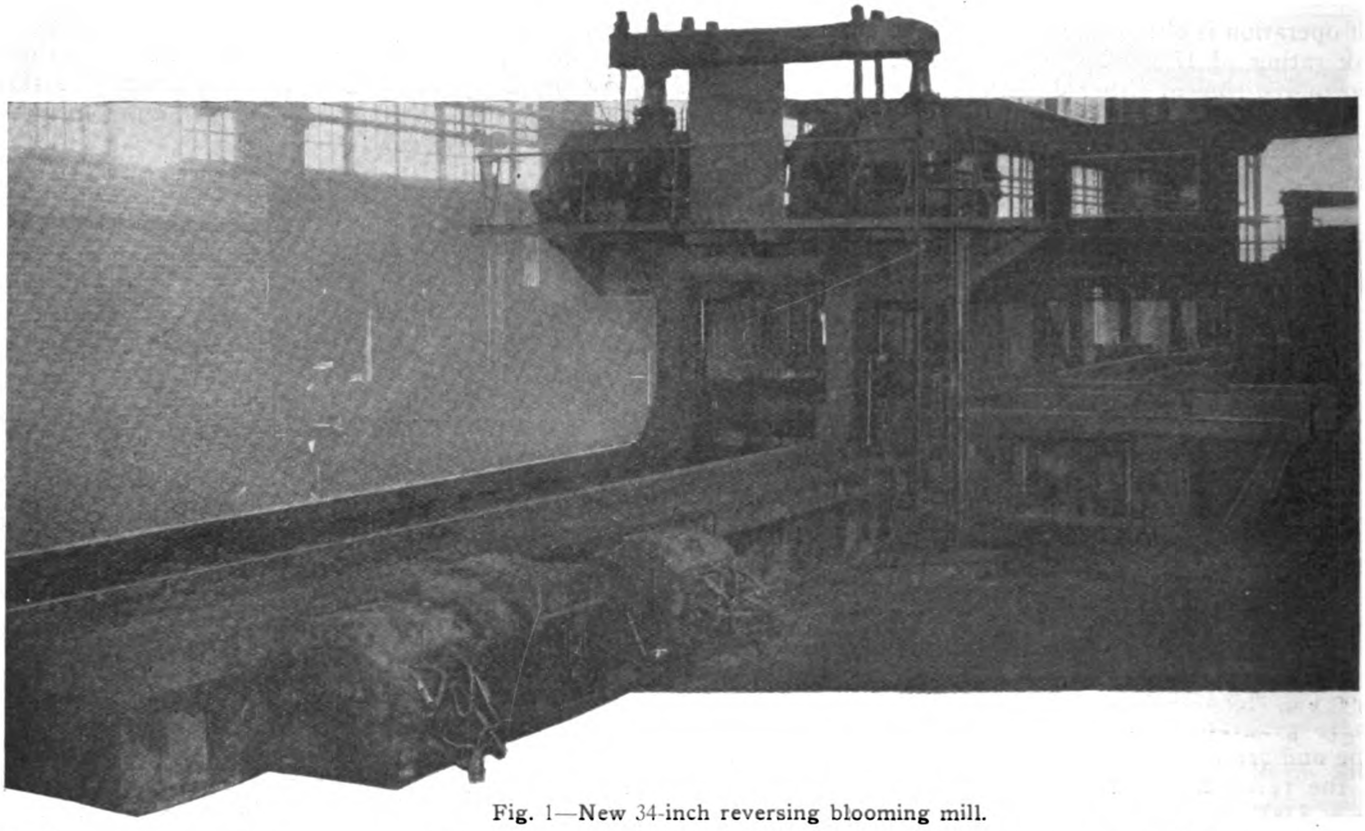

Fig. 1—New 34-inch reversing blooming mill.

Blooming and Continuous Mills at Sharon

Sharon Steel Hoop Company Operating New Thirty-four-inch Blooming and Twenty-inch Continuous Mill—Mills Electrically Driven—Description of New Additions.

Since acquiring the property of the Youngstown Iron & Steel Co., the Sharon Steel Hoop Company has installed two new 75 ton open hearth furnaces, making a total of six furnaces at this plant; one new four hole soaking pit furnace making a total of four pit furnaces; a new electric driven blooming mill with all the necessary accessories with a 21-inch tandem slab and sheet bar mill. This mill equipment takes the place of the 30-inch bar mill and the 24-inch universal mill which the Youngstown Iron & Steel Co. built in 1915.

The two new open hearth furnaces were similar in design to those already in operation at the plant. They were equipped with Blair electric operated valves and electric operated door lifts. Another charging machine and a 150-ton ladle crane, built by the Morgan Engineering Company, were installed. Thus giving double handling equipment for both charging and tapping the furnaces.

Three Morgan producer gas machines were installed for each furnace. Two of these machines will operate a furnace with the third for use when running on poor coal.

Concrete storage bins were built in the stock yard and so arranged that the raw materials may be dumped from the railroad cars directly into the bins and the materials then loaded into the charging boxes with a grab bucket operated from an overhead crane.

A 34-inch electric driven, two-high, reversing blooming mill, with manipulator and tables, built by the Mackintosh-Hemphill Company, was installed. This mill is driven by a 9,000 hp reversing direct current, 700 volt motor having a speed of 0 to 100 rpm Fig. 13 shows this Westinghouse motor as it is installed at the mill.

This motor is capable of delivering 1,000,000 feet pounds torque at 47 rpm. The motor is liberally designed to withstand the peaks encountered in reversing blooming mill drive, and is provided with a thrust bearing to protect it from the severe mechanical shocks of the mill such as the breaking of a spindle. The motor is artificially ventilated, the induction motor driving the blower being so interlocked with the main dc breaker in the reversing motor circuit that the breaker cannot be closed unless the blower is in operation. The reversing motor is controlled from the mill operator's pulpit by a master switch. Once the flywheel set is brought up to speed and the main circuit breaker closed, the reversing motor is controlled almost entirely from the pulpit in the mill.

The ease and rapidity with which this motor can be started, stopped or reversed, shows it to be inherently adapted to this class of service. This motor

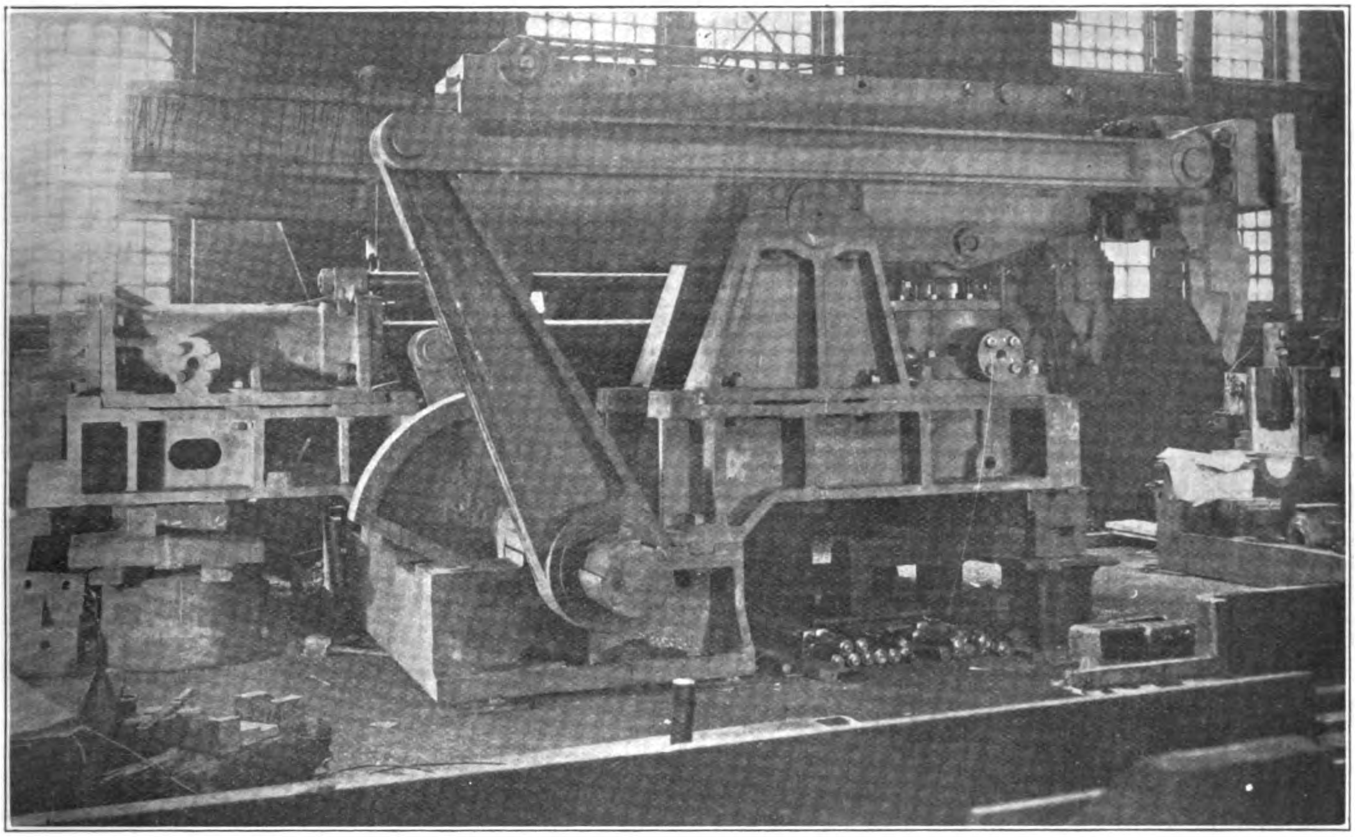

Fig. 2.

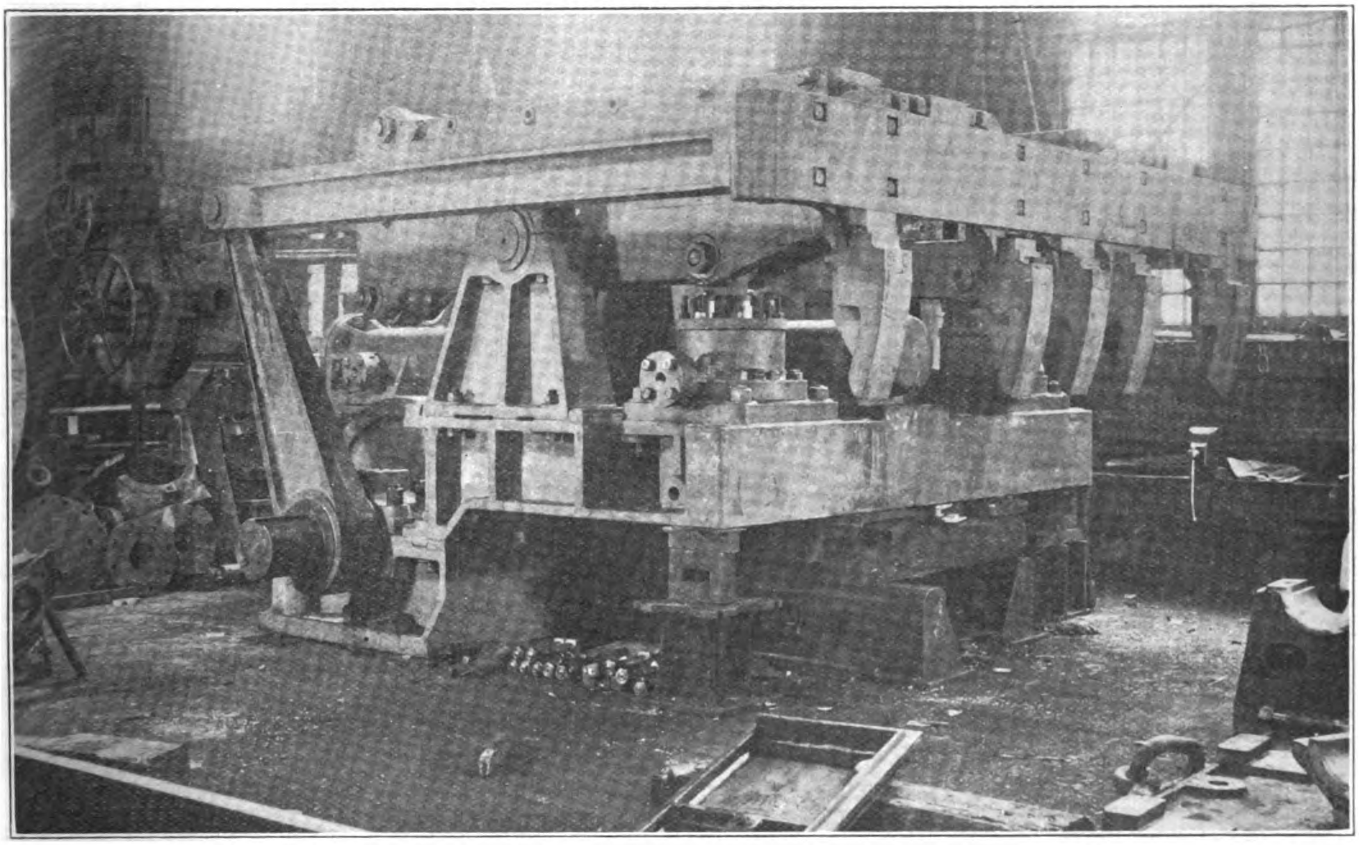

Fig. 3.

Figs. 2 and 3 show views of the Mackintosh-Hemphill type manipulator, which is one of the features of the 34-inch blooming mill. This is so designed that it has no racks or mechanism underneath the tables. The tilting feature is new, inasmuch as the whole moving side guard on the tilting side is raised up and has hanging on it several tilting fingers which catch the piece and turn it over.

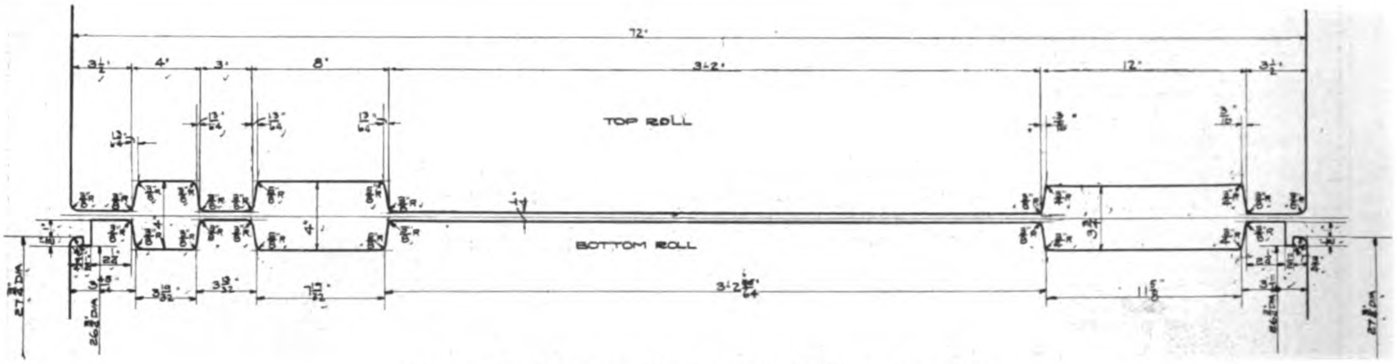

Fig. 4—Design of rolls for 34-inch blooming mill.

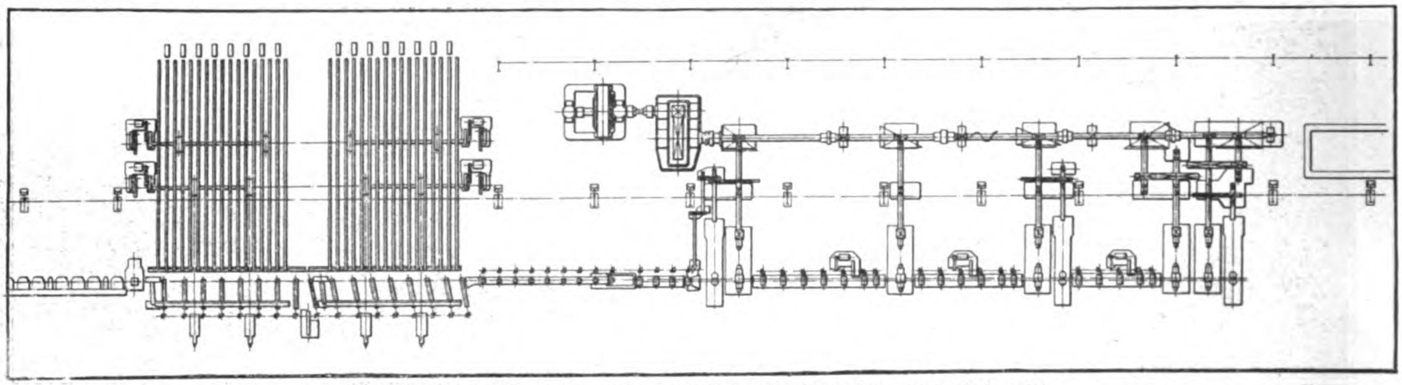

Fig. 5—General arrangement of 21-inch sheet bar and slab mill.

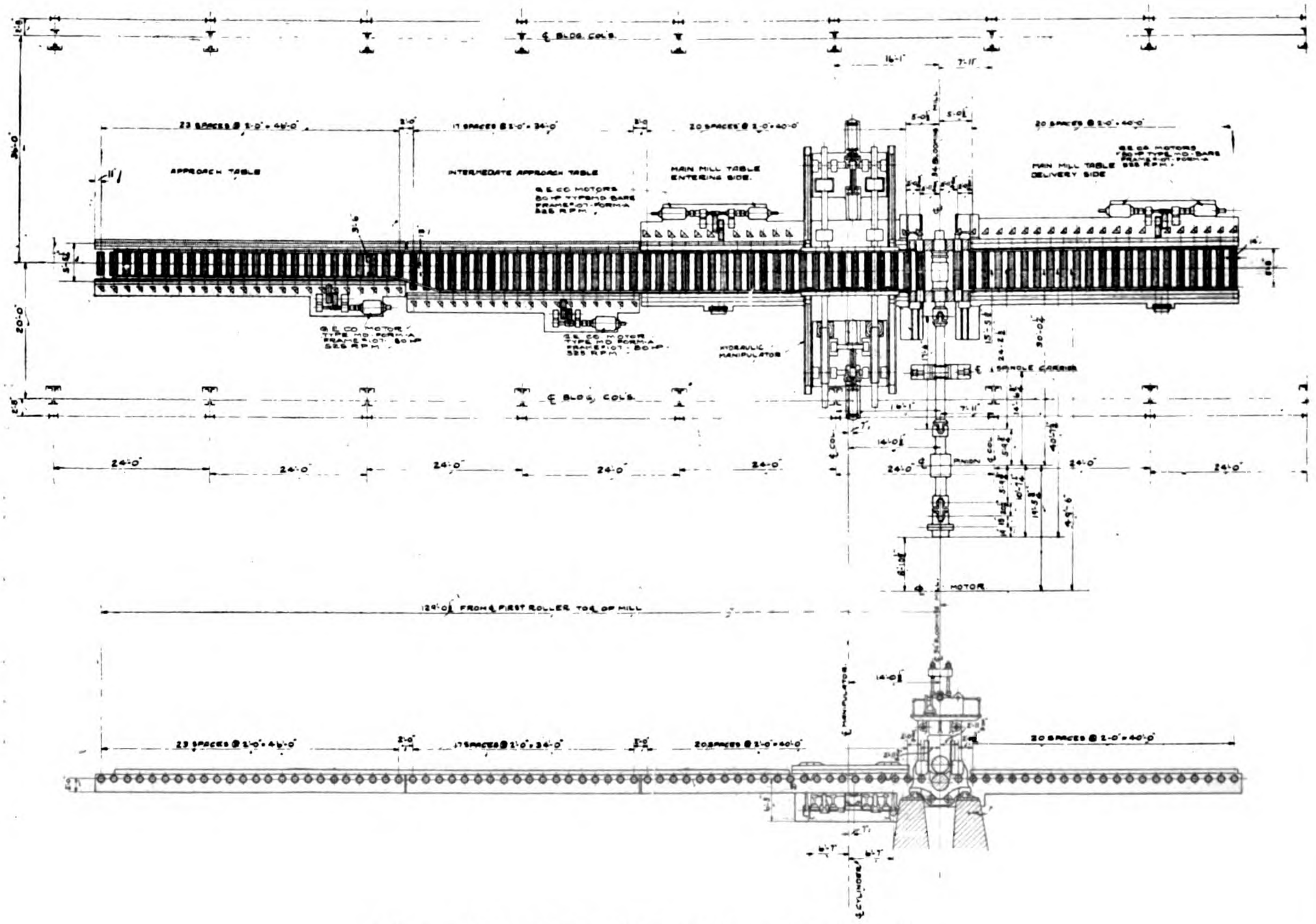
APPROACH TABLE
INTERMEDIATE APPROACH TABLE
MAIN MILL TABLE ENTERING SIDE
MAIN MILL TABLE DELIVERY SIDE
HYDRAULIC MANIPULATOR
PINION
MOTOR
24'-0"
129'-0" FROM FIRST ROLLER TO ℄ OF MILL

Fig. 6—Plan and elevation of 34-inch blooming mill.

drives the mill without any sign of distress when taking two to three-inch drafts on almost every pass when rolling 22-inch ingots to approximately 4x8 inches and to 6x18 inches.

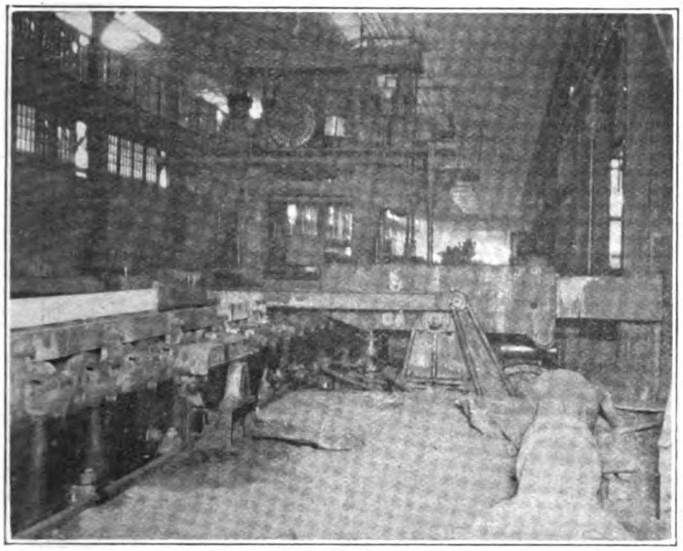

Fig. 7—Approach side of 34-inch blooming mill.

The reversing motor receives its power from a 2,250 kw, 700 volt, 352 rpm direct current shunt wound generator which is designed to withstand the same peak load as encountered by the reversing motor. This generator is driven by a 1,500 hp alternating current motor. This motor is designed to operate on a three phase, 2,200 volt, 60 cycle circuit and is of the wound rotor type. A 60,000 pound flywheel is mounted on the same bed plate with the motor and generator set, and between the two machines. This flywheel is completely enclosed with a sheet iron cover to reduce the windage losses and also to afford protection to the operator. The flywheel bearings of this set are water cooled as an emergency feature. Figs. 12 and 13 show the motor generator set as installed in the powerhouse. These figures also show the control panels for handling this equipment.

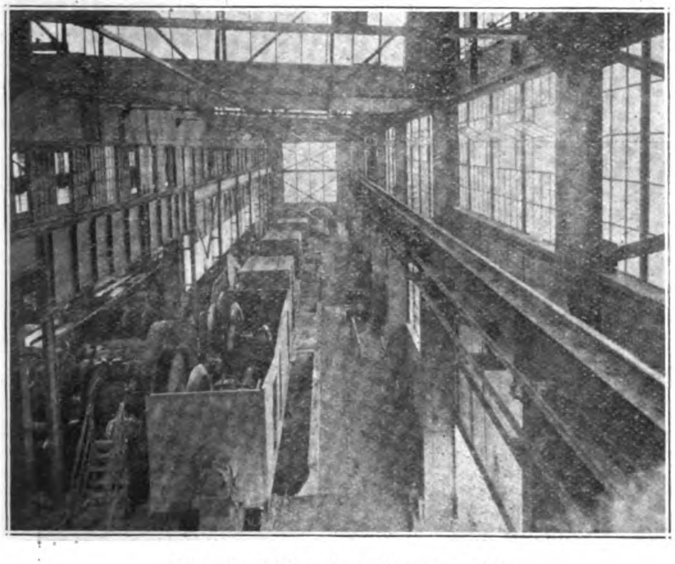

Fig. 8—Drive for 21-inch mill.

A liquid slip regulator limits the peaks and equalizes the input to the flywheel set. When the load on the ac motor reaches a predetermined value, the regulator introduces resistance in the secondary which causes the motor to decrease in speed, thereby allowing the flywheel to give up some of its stored energy, and hence to absorb the peak loads. When the peak load goes off, the regulator cuts out the resistance in the secondary and thus brings the flywheel back to full speed. The regulator is so arranged that the ac motor cannot be started until the maximum resistance is inserted in the secondary by means of the regulator being wide open. The switching of the ac motor is so arranged that the flywheel set can be brought to a standstill within a short space of time by opening the forward primary oil breaker and closing the reverse primary oil breaker.

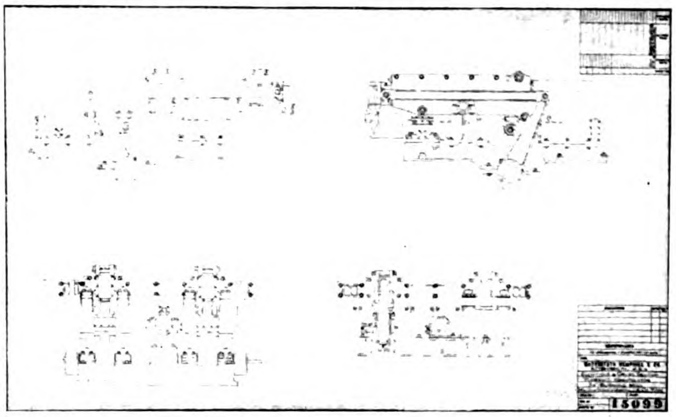

Fig. 9—General drawing of manipulator.

The reversing motor and dc generator are separately excited, receiving this excitation from a small induction motor driven exciter set.

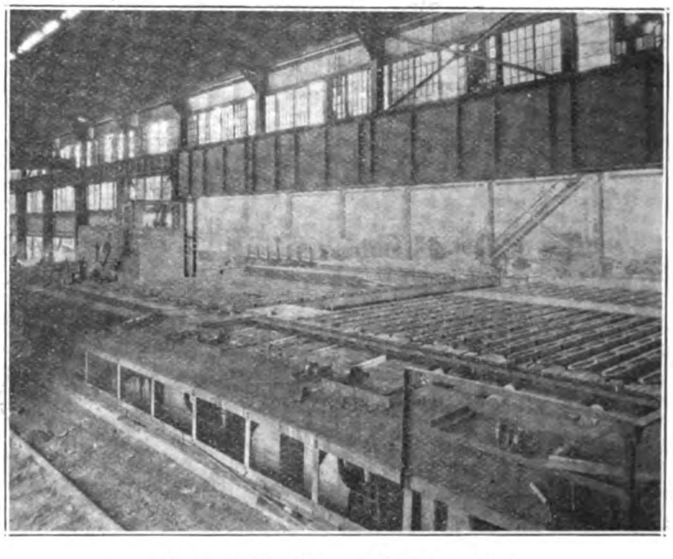

Fig. 10—Cooling beds for slabs.

There are two synchronous motor generator sets in the powerhouse, as shown in Fig. 13 for supplying the direct current power to the auxiliary motors

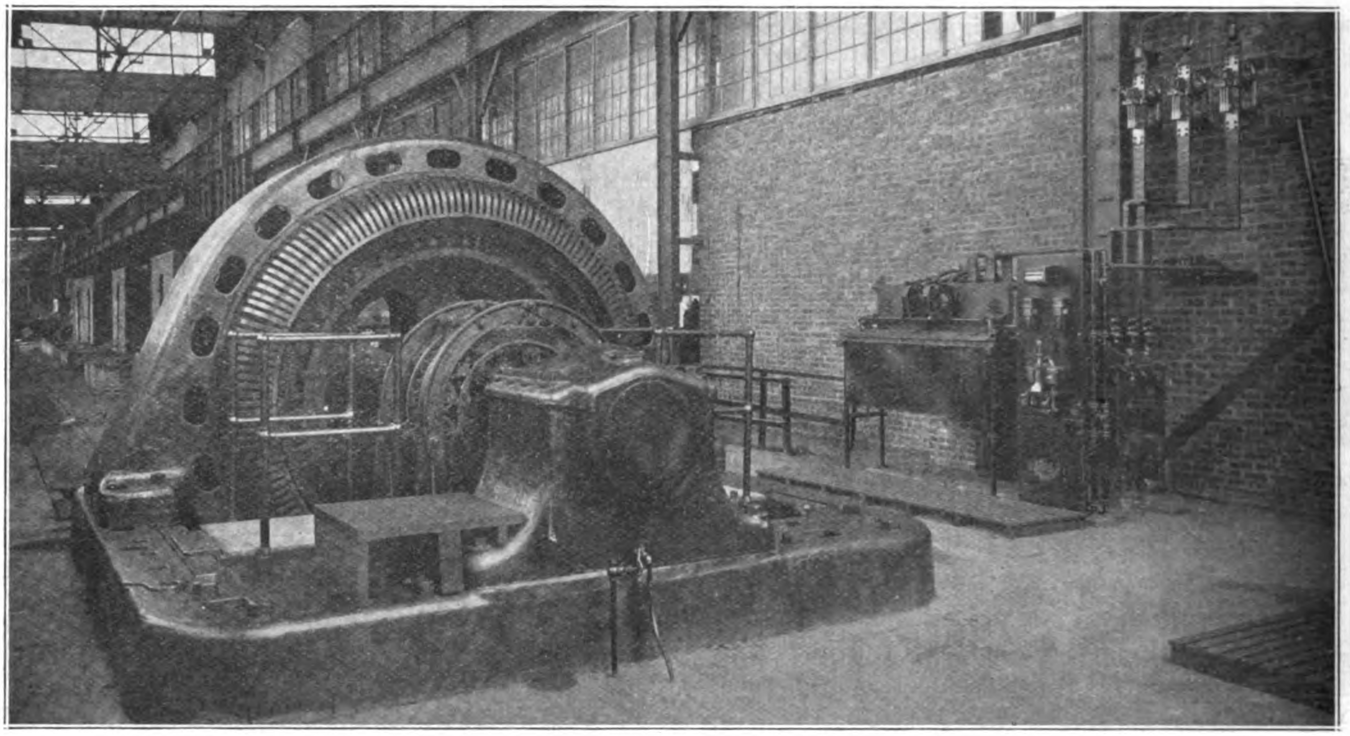

Fig. 11—4,000 hp motor for driving 21-inch mill.

around the plant. Both are 250 volt machines; one is a 750 kw, and the other a 500 kw generator.

A 100 kw turbo-generator for emergency use is provided in case the power from the power company is off for any length of time. This unit will furnish enough power to keep a part of the service pumps running and furnish some lights.

This plant uses central station power throughout, which is purchased from the Republic Railway & Light Company. An outdoor substation was installed on the company's property about a quarter of a mile from the power house. The power is purchased at 22,000 volts and is stepped down to 2,200 volts through six 1,500 kva outdoor oil transformers. A spare transformer is kept in the outdoor substation for emergency. The oil circuit breakers for use with these transformers are electrically operated from the powerhouse by direct current power. This direct current is supplied by a small flywheel motor generator set in the powerhouse which, in turn, receives its power from a small transformer in the outdoor substation.

This small flywheel set was designed to be in operation at all times when power is on the 22,000 volt line, there being no switches between the induction motor of this set and the 22,000 volt line. The flywheel was designed to maintain the speed of the set so that at the end of a certain period of time after the power failed, the generator would be capable of delivering the necessary power for operating the oil circuit breaker. By this means, the operator can clear the outdoor substation from the power house after the power has failed.

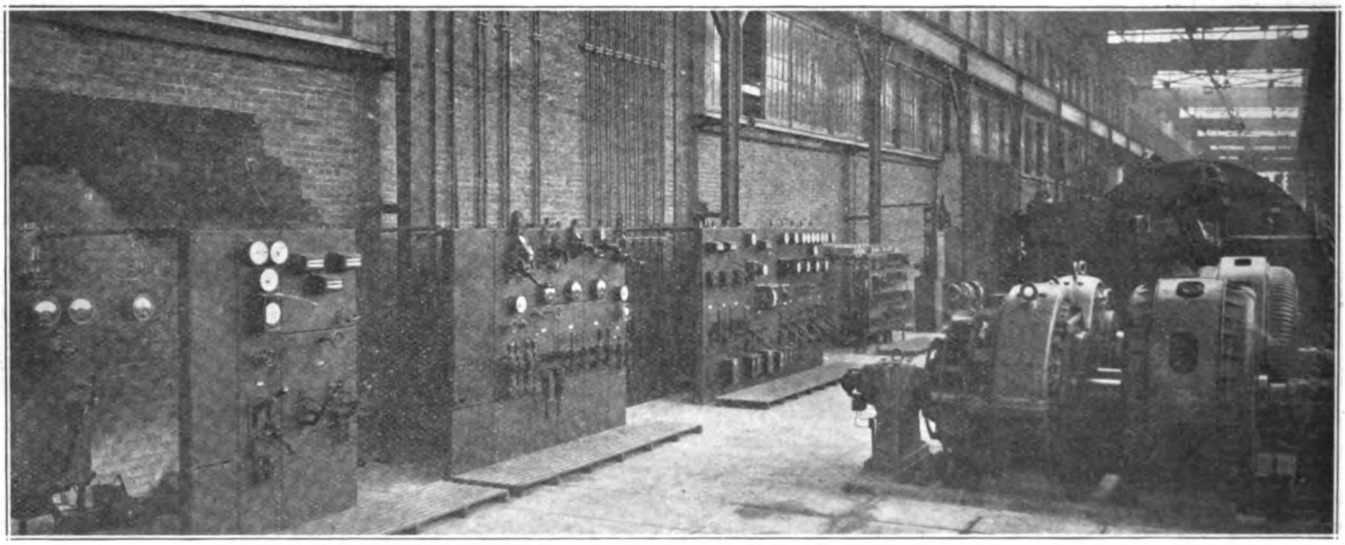

Fig. 12—Power house showing switchboards, motor-generator sets and large motor set for operating reversing mill motor.

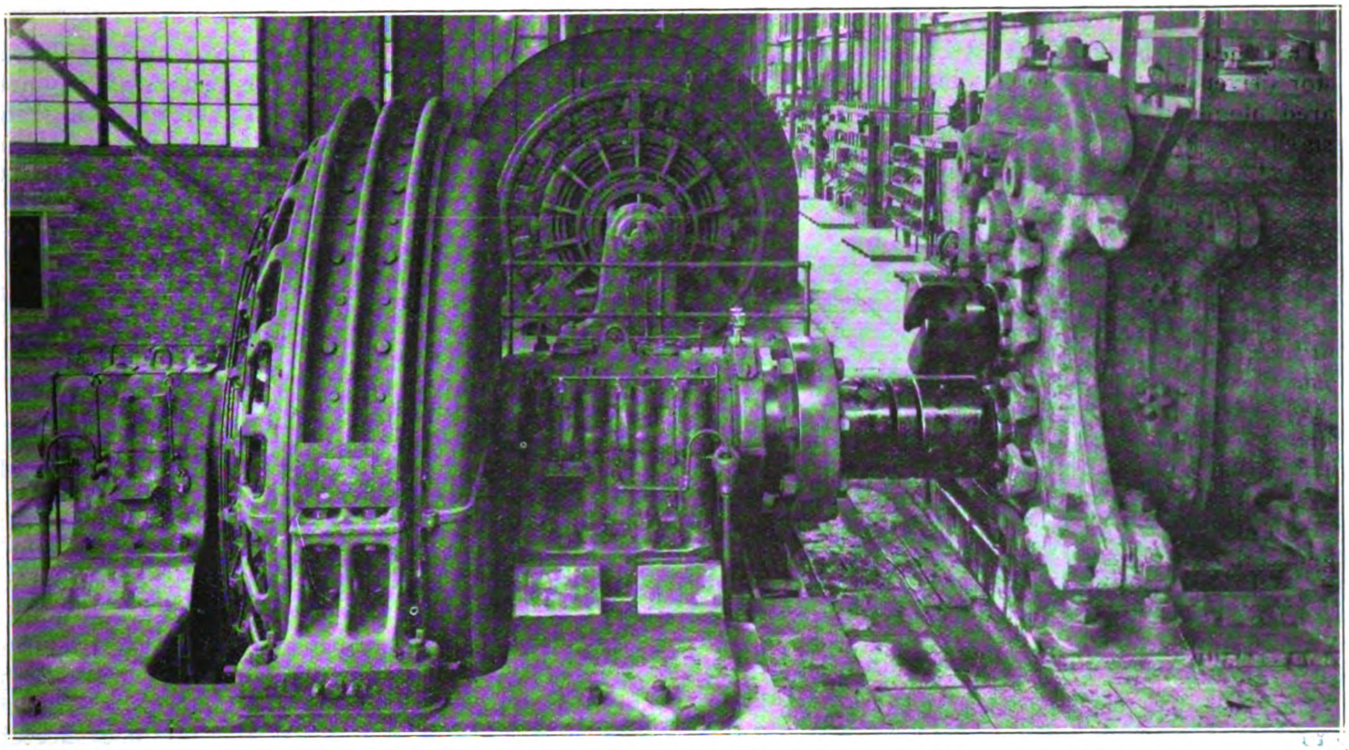

Fig. 13—Reversing mill motor and motor-generator set installed in power house.

The 34-inch two-high reversing blooming mill was designed and built by the Mackintosh-Hemphill Company and is of the latest standard design. The receiving side of this mill is shown in Fig. 7, and the delivery side in Fig. 1. The rolls in this mill are 30 inches in diameter by 72 inches long and have a lift of 28 inches. The screw-down mechanism is operated by two motors in series. All gears are totally enclosed and running in oil. The screwdown is of the hydraulic balance type. The feed rollers are driven by the extensions of the table side shafts, making one continuous drive for each side of the mill. The mill is equipped throughout with universal couplings, to take up any back lash due to reversing.

All mill tables are of the latest design with cast steel rollers and gears. The gears have cut teeth and are totally enclosed, running in oil. All tables are motor operated.

The special feature in connection with this installation is the hydraulic manipulator which is of the design known as the Mackintosh-Hemphill Company type manipulator. Fig. 9 shows a general drawing of this manipulator. This manipulator is so designed that it has no racks or mechanism of any kind underneath the tables, everything being so laid out that it comes outside of the tables at all times. The tilting feature is new, inasmuch as the whole moving side guard, on the tilting side is raised up and has hanging on it several tilting fingers which catch the piece and turn it over. This is accomplished by means of a tilting cylinder placed alongside the table beams. The manipulator is self-contained and has no connection to the table whatever except on the pusher side where the end of the pusher bars are carried on the table beam.

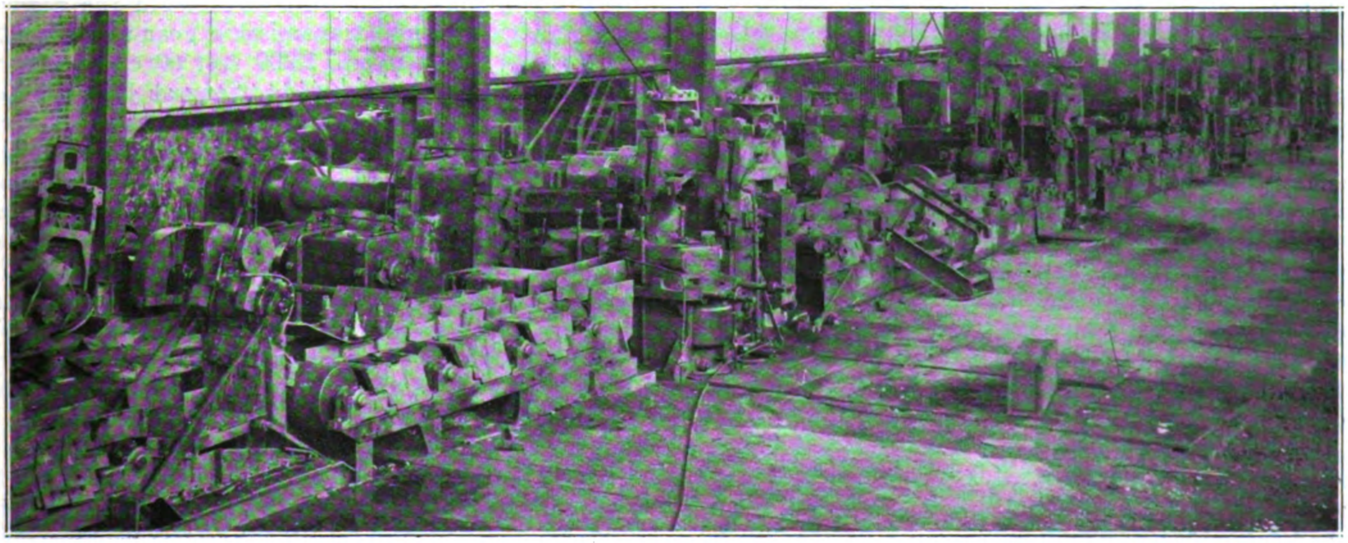

Fig. 14—21-inch mill delivery end.

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The shear approach table is of standard design, motor driven and adapted to fit into a 10x10 verticle geared bloom shear. The shear delivery table is so designed that the tilting and stationary sections may be moved away from the shear a distance of three feet to allow the crop ends and small slabs to drop into a chute and then into the scrap box. The table is moved in and out and also tilted by means of hydraulic cylinders.

Following the blooming mill shear is a 21-inch continuous mill complete with accessory equipment of shears, tables, cooling beds, etc., which was furnished by the Morgan Construction Company of Worcester, Mass. This mill produces from the direct ingot heat sheet bar 8 inches in width from 6 2/3 pounds to 46 pounds per foot, and 12 inch sheet bar from 10 pounds per foot upwards. This mill also rolls edged slabs 2 inches thick and 7½ to 16 inches in width for later rerolling in the hot strip mill of the Sharon Steel Hoop Company at Sharon.

The capacity of this mill is limited only at the present time by the supply of hot steel from the blooming mill. Its ultimate capacity can be developed up to 100 tons per hour. The product of the blooming mill comes to the 21 inch mill in the form of slabs which are two inches thick and eight to twelve inches wide for sheet bar and six inches thick, and of suitable width for the edged slabs that are intended for the hot strip mill.

The general arrangement of the 21 inch mill, cooling beds, and drive is shown in Fig. 5. It consists of five stands of horizontal rolls, and three power driven vertical edging rolls. The use of these vertical power driven edging rolls precludes the necessity for tongue and groove passes, and permits the rolling in the entire range of product on the same plane cylindrical rolls. In other words, no roll changing is required to get the full range of sections for which the mill is designed. The vertical rolls also render it possible to produce sheet bar and slabs of exceptional accuracy in width and quality of edge. When rolling sheet bar, the first and second edging mills are employed, and free vertical loops are thrown after the second, third, and fourth horizontal passes. When rolling slabs, the second and third edging mills are in use. After the second pass, the tandem rather than the pure continuous method of rolling is practiced; that is, the bar runs free between roll stands, as shown in Fig. 14.

The mill is driven throughout by high carbon, cast steel, cut bevel gears, as shown in Fig. 8 . The pinion housings contain herringbone pinions which are cut from solid high carbon steel forgings, and are of the "built-up" type standardized by the Morgan Construction Company. The two halves of the pinion are machined separately, and have their teeth cut before they are shrunk on the pinion center. The roller straightener tables have dustproof, self-oiling bearings, and cut steel gears.

Immediately following the mill is the well known Edwards-Carroll patented steam flying shear, as shown in Fig. 14, so essential to the successful operation of high speed continuous mills. The continuous billet and sheet bar mill could not have established itself so firmly for the production of small billets and sheet bar from the direct ingot heat as an adjunct to the blooming mill without the steam flying shear which solved the problem of caring for a stream of metal issuing from the finishing stand of mills of this nature at delivery speed which frequently attain 600 feet per minute.

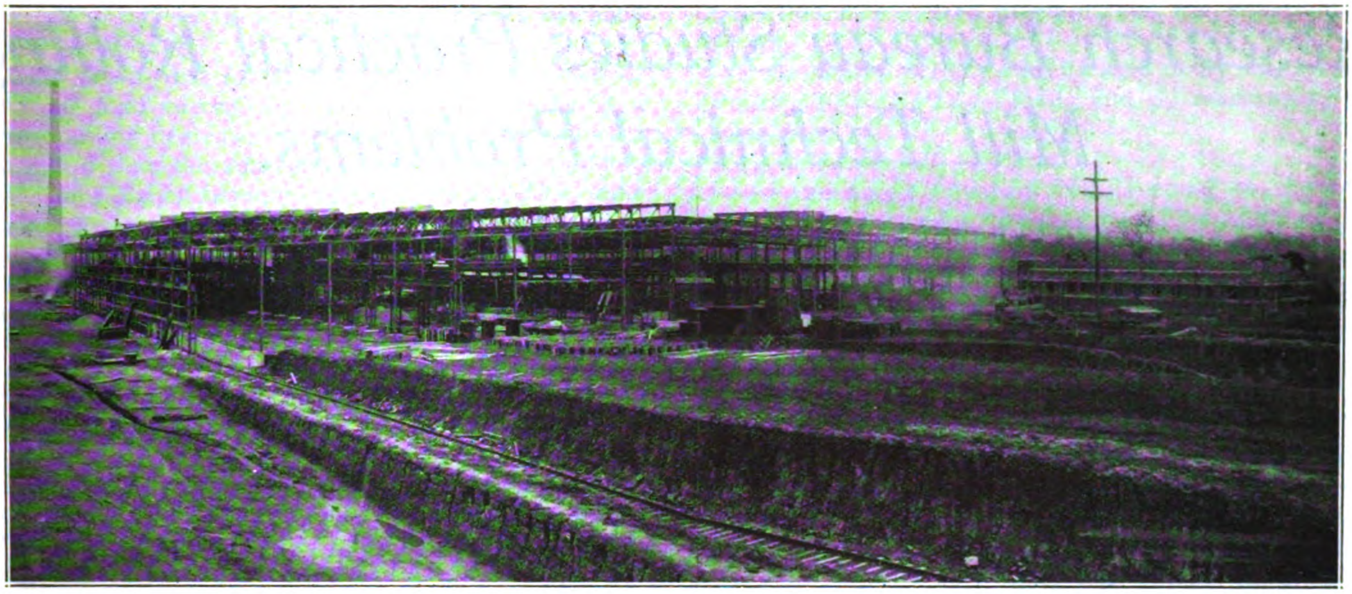
After the sheet bar has been cut by the steam flying shear into 30 foot to 35 foot lengths, it is, in this case, carried across the skew table to the bar piling rolls which stack it in the piling bin. This bin has adjustable sides so that any widths up to 15 inches can be piled in stacks up to 30 inches in height for the convenient handling by the crane.

A skew assembling table is also provided with a disappearing stop. This table is employed when the mill is rolling slabs. They are assembled in batches on this table and then pulled onto the cooling bed by a traveling straight edge, as shown in Fig. 10.

The general arrangement of this 21 inch mill has been purposely made so that it can be used later as a roughing mill for an 18 inch Morgan continuous sheet bar and billet mill. When this additional mill is installed, the 21 inch mill will not produce sheet bar, but will deliver a slab two inches thick to the 18 inch mill which will finish it into sheet bar, so relieving the blooming mill which will then not be called upon to roll slabs down to two inches in thickness, but can supply all slabs to the 21 inch mill at a thickness of six inches.

The mill is driven by an electric motor through a reducing gear unit. The latter was designed and built by the Morgan Construction Company. This gear and pinion are also of the "built-up" herringbone type. The two halves of the gear ring are bolted to a permanently shrunk and keyed gear center which remains in place on the gear shaft during the entire life of the gear unit as the gears can be replaced without disturbing the gear center. The bearings on the gear unit are of the chain oiled type. The gears are fully enclosed in oil-tight, horizontally split gear casings so arranged that the gear is readily asscessible for examination. A small heavily stressed breaking spindle is interposed between the pinion and motor shaft in order to definitely limit the stresses in the reducing gears and in the mill transmission gear and shafts.

A 4,000 hp, 360 rpm, 2,200 volt 60 cycle slip ring induction motor built by the General Electric Company drives the mill. Continuity of service is a vital consideration in the design of motor and control. Large air gap, cast steel, rotor spider; rugged box girder, stator frame; thrust collar on the low, heavy pedestal at the coupling end to withstand the lateral thrust due to diagonal fracture of the breaking spindle; heavily insulated windings reenforced by wedges and binding bands to prevent movement in the slots, are among the well recognized characteristics of this type of motor. Provision is made for moving the stator parallel to the shaft to facilitate examination of the rotor, and also for movement at right angles to the shaft for adjustment of air gap. The brush holders are supported from the base, thus minimizing vibration and increasing the life of the collectors. This motor is shown in Fig. 11.



View showing modern construction and size of sheet rolling mill being built by the Eastern Rolling Mill Company.

Sheet Rolling Plant Nears Completion

Twelve Finishing Hot Mills, Eight Stands of Roughing Rolls and Twenty Stands of Cold Rolls Electrically Driven to Roll High Grade Automobile Sheets.

ONE of the most modern sheet mill plants in the country is nearing completion at Baltimore, Md., and will be placed in operation early in the new year. The mill is being built by the Eastern Rolling Mill Company, which comprises the following active organization:

J. M. Jones, president and general manager; C. E. F. Clark, vice president and treasurer; L. J. Jones, secretary and assistant to president; J. A. Downey, assistant treasurer; Joseph Hirschmann, chief engineer of construction; Charles A. Pennock, general superintendent; A. J. Hazlett, sales manager.

The plant which is intended for the production of high grade automobile sheets is being erected on a site in the suburbs of Baltimore, known as the Canton district, and situated halfway between Baltimore and Sparrows Point. This plant as shown in the illustration is to be the last word in sheet mill construction.

The site comprising 50 acres is well located as regards freight rates and shipping facilities and will be covered with mill buildings of strictly all steel construction and of the most approved type, permitting perfect ventilation which will insure a cool mill. The mill buildings are 996 feet long with a total width of 375 feet.

The main bays are 80 feet span and the hot mills will be driven by two separate units, each comprising a 1,500 hp General Electric motor connected to single reduction gear drives which will be furnished by the Mesta Machine Company.

There will be 12 finishing hot mills and eight stands of roughing mills, the rolls will be 30 inches in diameter and the housing will be extra massive, to take care of the maximum pressure with a minimum amount of spring. These mills are being constructed by the National Roll & Foundry Company, of Avonmore, Pa., and will be of extra heavy construction throughout.

The mill furnaces which will be furnished by the George Hagan Company are of the stoker fired type and equipped with pushers for charging the sheet bars. There will be 20 stands of cold rolls furnished by the Hyde Park Foundry & Machine Co., and driven through a Falk gear drive by a 750 hp motor.. There will be three Mesta pickling machines and a modern annealing department and a separate finishing department for the handling of high-grade sheets.

A scrap bundling press built by the Galland Henning Company, of Milwaukee, is also being installed to hydraulically compress the scrap from the sheet shears into cubes for use in the open hearth furnaces.

A steam power plant, consisting of two 250 hp Heine boilers, with a brick stack 150 feet high, is being added in order to furnish steam for the pickling machines and acid vats.

It is also the intention to install a unique feature in the way of a steam drying arrangement to dry the pickled sheets before annealing to prevent stains on the surface of the highly finished sheets.

A separate coal track is provided where the coal can be dumped into bins and then by means of a grab bucket and trolley distributed to the furnaces.

A lavatory for the convenience of the employes is being erected in the center of the building, while an up-to-date brick office building, designed by G. S. Childs, architect, is also being erected.

J. M. Jones, president and general manager, is conceded by the trade to be one of the best posted men in the sheet and tin business, and with his corps of assistants, all practical men along this line of manufacture, there is an assured success for this enterprise from the beginning.

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Research Bureau Studies Practical Rolling Mill Technical Problems.

Description of Equipment to Be Installed at Rolling Mill Research Bureau for Experimental Measurement of Friction Losses and Spreading Forces on Rolls and Roll Housings.

By W. B. SKINKLE,
Director of Rolling Mill Research.

THE great need of accurate knowledge of the forces acting on rolls and the friction losses on roll necks in different types of rolling mills has prompted the author to write an article concerning a description of a device soon to be tried out on the experimental mills of the Bureau of Rolling Mill Research.

By means of this equipment it is expected that experimental data will be secured that will give positive, accurate knowledge, not only of the relative values of the various lubricants and bearing metals used on roll-necks, but also of the spreading forces acting on the rolls; from which the stresses in rolls and housings may be calculated to a far greater degree of accuracy than is at present possible.

The device consists of two hydraulic supporting cylinders marked Cylinder No. 1 and Cylinder No. 2 in Figs. 1 and 2, located in the bottom of the roll-housing window and so arranged that they can easily be removed and replaced by a filler.

The carrier for the bottom roll rests on the plungers of these cylinders in such a manner that the forces acting on the roll neck are recorded by the resulting hydrostatic pressure in these cylinders. Fig. 1 shows a diagramatic arrangement of these cylinders marked Cylinder No. 1 and Cylinder No. 2 shows a bloom between the upper and lower rolls with the lower roll carrier and cylinders. The full lines show the position of this carrier under static conditions (condition of rest). The conditions existing at the lower roll neck being greatly exaggerated for the purpose of illustration.

The total spreading force F*, due to the bloom pinched between the rolls, will cause a heavy force P, to be applied about as indicated in Figs. 1 and 2. Under static conditions this force would be transmitted from the roll body to the neck and would be applied to the bearing as indicated by the arrow A in Fig 1. Such an application of forces would cause one-half the load P, on each bearing, to be carried by cylinder No. 1 and the other half by cylinder No. 2.

The proportion of the total force F, which is distributed to each neck of the rolls will depend on the location of the pass in the roll body and can readily be figured by the well known principles of beam reactions.

Where rotation starts, and the bloom is being rolled, the point of contact between roll neck and bearing changes to some other point, the force P is then applied to the bearing as indicated by the dotted arrow B, and the lower roll carrier has a tendency to assume a position indicated by the dotted lines, using the roller C as a fulcrum point; the roller D lifting off its seat. The position indicated by these dotted lines in Fig. 1 is of course greatly exaggerated for the purpose of illustration. It is however, vitally important that the bearing be perfectly free to rotate as indicated, and that no forces other than the cylinders Nos. 1 and 2 be interposed to prevent this rotating tendency. (In actual practice it is expected that not more than .003 inch or .004 inch of movement will be obtained on these cylinders between no load and their maximum carrying capacity of 250,000 pounds each.)

When the contact point has moved to a place where it slides back as rapidly as it tends to climb, the angle of sliding friction has been reached and a condition of equilibrium is again established.

These conditions are shown and analyzed in Fig. 2. The pressures on the supporting cylinders will no longer be equally distributed, as in the case of static conditions, but will be much heavier on cylinder No. 1 than on cylinder No. 2.

In the analysis of these conditions the following symbols will be used.

P = Total resultant force on the roll neck, in pounds.
R = Radius of the roll neck in inches.
μ = The angle whose tangent is the coefficient of friction.
D = Distance from center line of roll housing to center line of supporting cylinder.
d = Distance from center line of roll neck bearing to the point of contact between the neck and bearing.
N = Some fraction of P greater than one-half.
M = Some fraction of P less than one-half.

If equilibrium in a "free body" is maintained the following conditions must be met.

1. The sum of all horizontal or vertical forces acting on the body must be equal to zero.
2. The sum of the moments of all forces acting on the body, taken about any point, must equal zero.

Fulfilling the first condition, as applied to the vertical forces on the lower roll neck bearing, we have

$$-P + NP + MP = 0$$

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* It is not the purpose of this article to enter into discussion of the complicated system of forces acting at the contact surfaces between rolls and bloom. Inasmuch as the rolls are able to move up or down and are restrained from horizontal movements in any direction by the bearings and roll housing the resultant of all forces acting, must be in a vertical direction.

then $NP + MP = P$ and cancelling the P's we have

$N + M = 1$

This shows that for each increase over one-half of the total load carried by cylinder No. 1 there is a corresponding decrease in the load carried by cylinder No. 2 and that the sum of the pressure on cylinders Nos. 1 and 2 must be equal to the force P. This same fact can be shown by taking moments about the point x where the roll neck applies its load to the bearing. In this case the force P has no lever arm. Its moment would therefore be zero, and it may be neglected. Taking moments about x we have

$+ NP (D - d) - MP (D + d) = 0$ which expands into

$NPD - NPd - MPD - MPd = 0$ (1)

Taking moments about Y the center of the roll neck we have

$- Pd + NPD - MPD = 0$ (2)

Subtracting equation (2) from equation (1) we have

$PD - NPd - MPd = 0$; or $NPd + MPd = Pd$ and canceling the Pd's we have $N + M = 1$.

The force P applied at X may be resolved into its component forces, one normal to the tangent of the contacting surfaces and the other parallel to this tangent. As shown in Fig. 2 the force normal to the tangent will be equal to $P \cos \mu$, and the tangential force will equal $P \sin \mu$.

These two component forces may then replace the original force P, and are indicated by dotted arrows applied to the point X.

If moments are now taken about the point Y it will be noticed that the force "$P \cos \mu$" has no lever arm, therefore a zero moment, and the equation becomes

$-P \sin \mu R + NPD - MPD = 0$ or by transposing $P \sin \mu R = NPD - MPD$ and by rearranging we have

$P \sin \mu R = (NP - MP) D$ (3)

In the above equation NP is equal to the total pressure on cylinder No. 1 and MP is equal to the total pressure on cylinder No. 2 also D is equal to the lever arm of one cylinder.

It will, therefore readily be seen that the difference between the total pressures on the cylinders, when multiplied by the lever arm of one cylinder; is the exact measure of the resisting forces due to friction on the roll neck and it is only necessary to multiply this quantity by the surface speed of the roll neck in feet per minute and divide this result by the radius of the roll neck, in inches to secure the number of foot pounds of work lost in friction at this point.

It will also be noticed that it is only necessary to divide this same quantity $(NP - MP) D$ by the sum of the recorded pressures and also by the radius of the roll neck in inches, to obtain the sine of the angle whose tangent is equal to the coefficient of friction between roll neck and bearing. This can be expressed mathematically as follows: re-arranging equation three we have

$$\sin \mu = \frac{(NP - MP)\, D}{(NP + MP)\, R} \qquad (4)$$

The sum of these quantities $(NP + MP)$ also gives

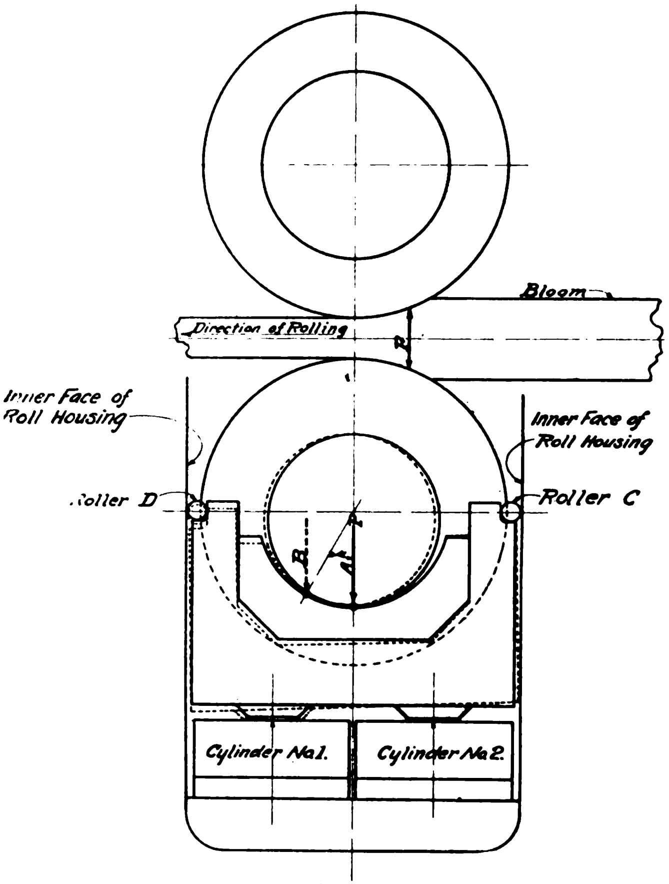


Fig. 1.

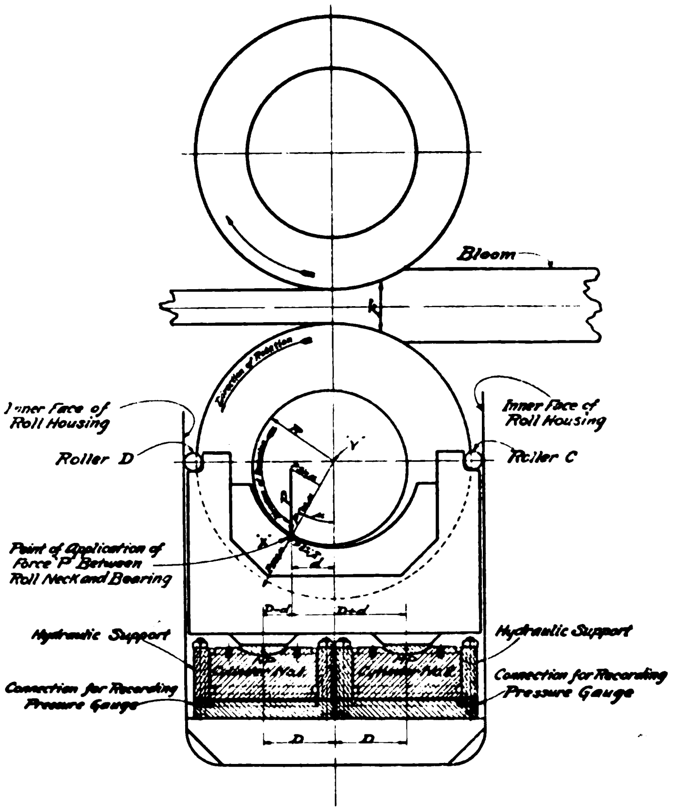

Bloom
Direction of Rotation
Inner Face of Roll Housing
Inner Face of Roll Housing
Roller D
Roller C
R
Y
X
d
Point of Application of Force "P" Between Roll Neck and Bearing
D-d
D+d
Hydraulic Support
Hydraulic Support
Cylinder No.1.
Cylinder No.2.
Connection for Recording Pressure Gauge
Connection for Recording Pressure Gauge
D
D

Fig. 2.

the load applied to the housing which carries that particular roll neck, and by adding these quantities obtained from the corresponding cylinders in the housing on the other end of the roll, the total load on the roll is obtained.

The foregoing is true only if the hydraulic support cylinders are frictionless. If these hydraulic cylinders were of the ordinary hemp packed plunger type the results obtained would be almost useless as the friction of the packing on the plunger would be very large and the exact amount of this friction would be very difficult if not impossible to obtain.

It will therefore be necessary to produce a frictionless hydraulic support cylinder. This, the author believes, has been obtained in the cylinder shown in Fig. 3.

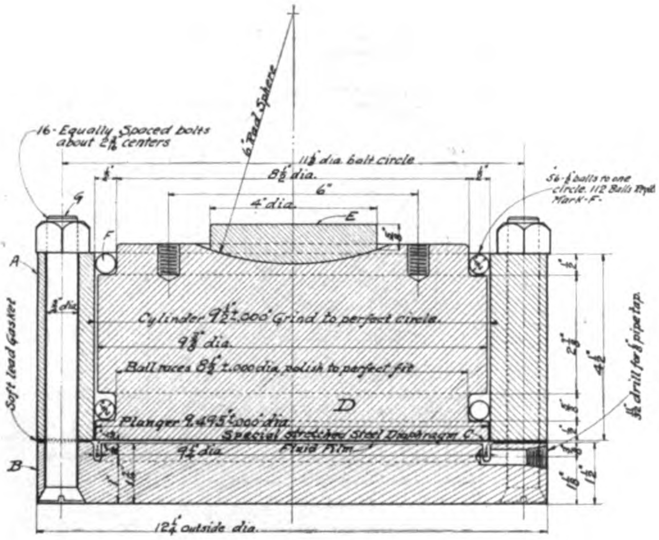

16-Equally Spaced bolts about 2 3/16" centers
6" Rad Sphere
11 3/4" dia. bolt circle
8 1/2" dia.
6"
4" dia.
E
56-1/2" balls to one circle. 112 Balls Req'd. Mark -F-
G
F
A
Soft lead Gasket
3/4" dia.
Cylinder 9 1/2" ±.000" Grind to perfect circle.
9 3/8" dia.
Ball races 8 1/2" ±.000 dia. polish to perfect fit.
D
Plunger 9.495" ±.000" dia.
Special Stretched Steel Diaphragm C
9 1/4" dia.
Fluid Film
B
12 1/4" outside dia.
2 3/8"
4 1/2"
1 1/2"
11/32" drill for 1/8" pipe tap.

Fig. 3.

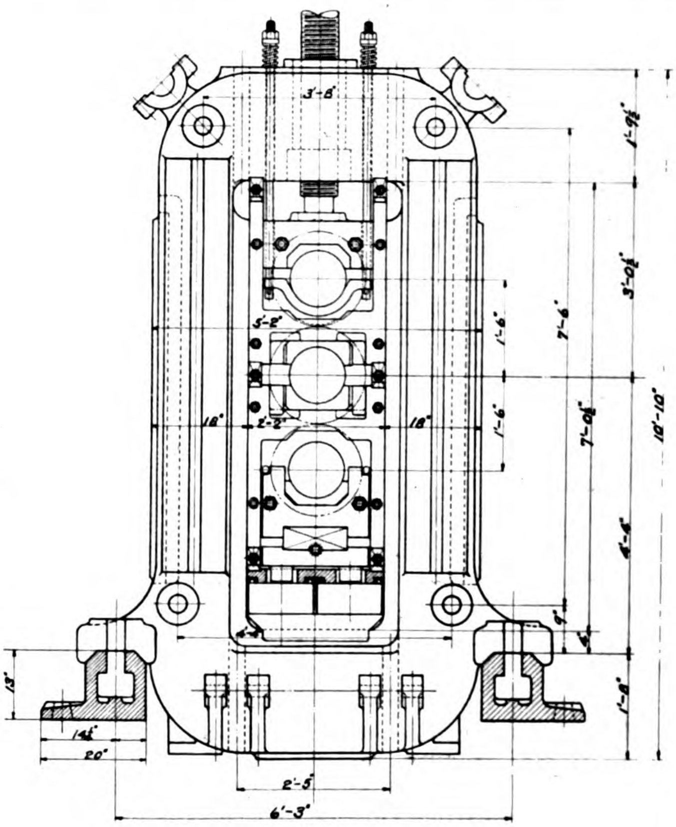


Fig. 4.

While it is recognized that no machine can be absolutely frictionless this cylinder so nearly approaches this ideal state that for all practical purposes it may be considered as frictionless.

The cylinder consists of an upper or guide cylinder A securely bolted to its base B by 16, ¾ inch bolts G. The base, which is really the cylinder proper, has a groove, 9¼ inch inside diameter, cut into it. The center portion of the base is then faced off to allow just a film of fluid not over 1/16 inch in thickness to act on a special stretched steel diaphragm C which is securely held in place by the friction between the parts A and B of the cylinder and is made tight on its lower side by a soft lead gasket. By this means the fluid is completely confined in the cylinder, the only escape being through the orifice leading to the recording pressure gauge. The plunger D never comes in contact with the fluid in the cylinder but rests on the upper side of the steel diaphragm C. These contacting surfaces must be very flat and true.

In order to avoid friction between the plunger D and the side walls of the guide cylinder A the plunger is turned ⅛ inch smaller in diameter than the guide cylinder on its upper parts, and .005 inch smaller in diameter where it rests on the diaphragm.

In order to prevent lost motion, or the plunger from tilting and shearing the diaphragm, and further to prevent the plunger from getting "off center" and having a rubbing contact with the cylinder walls; two rings of 56, ½ inch diameter steel balls each, marked F are provided.

The inside diameter of the guide cylinder A is ground to as nearly a perfect circle as possible and the grooves for the balls are ground and polished to a perfect fit.

When the plunger moves downward due to the application of a load these steel balls tend to lift off their seats and establish a rolling contact between the plunger and cylinder walls.

The only friction on this cylinder is the friction of these ball bearings, the internal friction of the steel in the diaphragm and the friction of the fluid on the pipes leading to their recording gauges.

These quantities are so small when compared with the maximum load of 250,000 pounds which each cylinder is designed to carry, that they may be neglected.

The displacement of fluid by the plunger when under load is equally small. Marks Handbook, page 251 gives the following information: "A pressure of 1 pound per square inch compresses liquids in volume as follows: Water 1 part in 300,000; mercury 1 part in about 4,700,000. For water in an iron pipe this corresponds to a compression of two inches per mile of length for a pressure of 10 pounds per square inch."

It will easily be seen that such a compression of the fluid will not disturb the roll setting. The only other factors entering into the plunger displacement will be the quantity of fluid necessary to move the needles of the recording gauges and the expansion of the short pipes leading to these gauges. Both of these factors are so small that they may be neglected.

The idea of this frictionless diaphragm cylinder is not new, but has had several stages in its development. It appears to have been originally invented by Mr. Emery who first applied it to the well known testing machine bearing his name. The general application of this invention was delayed by the fact that Mr. Emery measured the pressure in his hydraulic supports by means of a complicated balancing and weighing mechanism. The hydraulic support was made accessible to general use by the research work of Dr. A. Martens at the German government materials testing station, who measured the pressure in the hydraulic support by means of Bourdon pressure gauges, and who proved conclusively that the combination of hydraulic suport and pressure gauge forms the most accurate and desirable means for measuring, without friction or lost motion, forces of any magnitude and of any suddenness of application.

Prof. W. Trinks, head of the department of mechanical engineering at the Carnegie Institute of Technology first conceived the idea of applying cylinders of this type to roll necks, sometime early in 1916 and made drawings of a special roll housing for this purpose.

When the author was placed in charge of the organization of the Bureau of Rolling Mill Research and of the designs of the experimental mill he carried the development one step further by designing the present cylinders in such a manner that they would fit in the window of an ordinary roll or pinion housing, and could easily be replaced by a filler casting in case experiments not requiring their use were to be made.

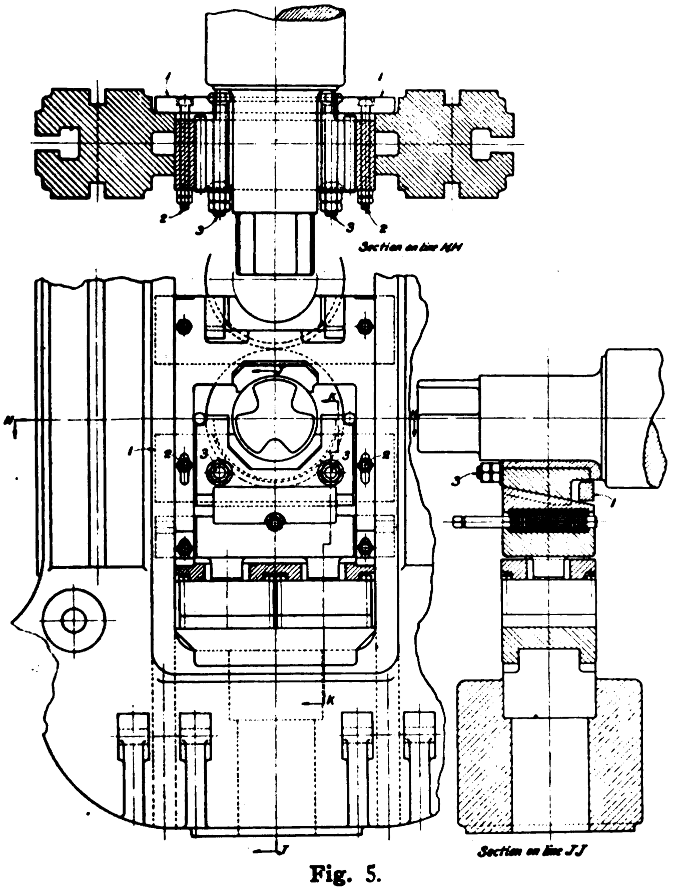


Fig. 5.

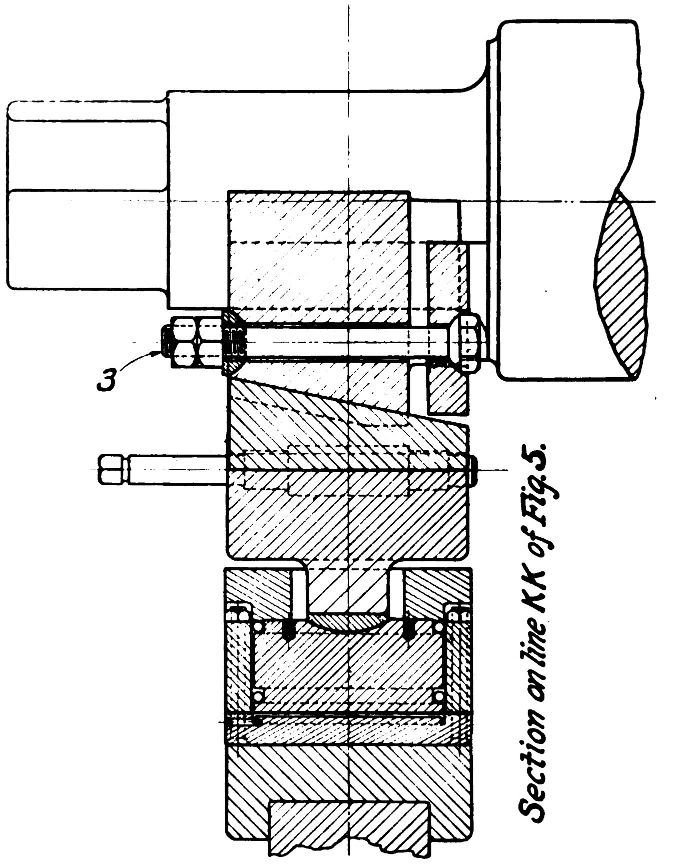


Fig. 6.

The first cylinder of this type is now in the course of construction and will be carefully tested and calibrated under a 600,000 pound compression testing machine before the final design is produced for the experimental mill.

Diaphragms varying in thickness from 1/64 inch to 3/64 inch are on hand and their relative merits together with the relative merits of mercury or water for the fluid will be carefully investigated before the final selections are made.

Fig. 4 shows a preliminary drawing of these cylinders applied to the 18 inch three-high bar mill and is somewhat different from that shown in Figs. 1 and 2. These last mentioned figures were taken from the 24 inch sheet mill with the neck brass "faked in" for the purpose of better illustration of the mechanical principles involved.

Fig. 5 shows the actual design of the same mill shown in Fig. 4 but on a larger scale and in complete detail.

There is one more important item which should be considered before bringing this article to a close. That is the friction of the end of the roll neck brass on the roll body.

The "thrust plate" marked 1 in Fig. 5 is held firmly against the inside of the roll housing by the bolts 2 and 3 and, unless a flexible connection between the lower roll carrier and this thrust plate was provided, would offer a very substantial resisting force acting against the rotating tendency of the lower roll carrier. To overcome this the bolts "3" are made with "ball joints" at their inner and outer ends. In this manner any retarding action due to the stationary thrust plate is avoided.

Fig. 6 is a section through this bolt and shows the construction just clearly described.

The importance of careful experiments on roll neck friction will be realized when, according to the best information at present available, between 40 per cent and 50 per cent of the total work of a blooming or bar mill engine is absorbed in friction on the roll necks.

These figures represent the best working conditions in rolling mill practice. For mills such as plate, skelp or sheet mills rolling wide, thin sections, which are often cold, the work lost in friction on the roll necks is frequently between 70 per cent and 80 per cent of the total work of the engine or motor.

The designs of the experimental mills are being worked out with extreme care, which of necessity involves a slow rate of progress. They offer a great many problems similar to the one just described. It is expected that these designs will be completed some time during the next three or four months and will be given to the public very shortly thereafter.

The Carnegie Institute of Technology is throwing open to members of the bureau, nearly $400,000 worth of building and equipment, free of all charges for rentals, etc.

More than half the money necessary to add this experimental rolling mill has already been definitely subscribed and the remainder is in sight, approved by officials of many different companies interested, but awaiting ratification of their various boards of directors.

The completion of this experimental mill will make the Bureau of Rolling Mill Research what is probably the largest and most complete steel research laboratory in the world.

Seamless Steel Tube Plant Being Built

Detroit Firm Begins Construction of Three-Million-Dollar Plant to Produce Twenty-five Hundred Tons of Seamless Steel Tubing Per Month.

THE Detroit Seamless Steel Tube Company has begun construction of a $3,000,000 plant on a 60-acre tract at Detroit, Mich. The first unit of the plant will cost $1,000,000 and will be completed about March 1, 1920.

The building plans call for a structure of steel and glass with brick and concrete facing. The plant proper will occupy a space of 350x700 feet. It will consist of three bays for manufacturing units, a separate heating plant and a two-story administration building. The three manufacturing units will be each 90 feet wide by 700 and 550 feet long and 20 feet high, to permit the use of traveling cranes and other labor saving machinery. The interior layout and special tube mill machinery was designed under the direction of C. A. Ross, mechanical engineer, and C. L. Stafford, mill superintendent.

The plant will have all the latest types of modern labor saving devices and machines. A powdered coal system will be used for all the heating and annealing processes used in manufacturing operations. The tube mills will be furnished by the Standard Engineering Company. The total capacity of the first unit of the new plant will be 2,500 tons of seamless steel tubing a month, the range of sizes being from one-half inch to six inches outside diameter, and No. 13 gauge and heavier. Cold drawn seamless steel boiler tubes and locomotive flues will be manufactured as well as mechanical tubing, used in the manufacturing of automobiles, tractors and trucks. The factory will contain an unusually complete forming department equipped to make practically any shaped tube desired.

The Detroit Seamless Steel Tube Company is the only manufacturer of seamless steel tubing in Michigan, having been established 19 years ago at its present location.

Shipping facilities of the new plant will be unexcelled. The Detroit Terminal Railroad tracks will run through the plant, bringing the raw material in on one side and carrying away the finished product on the opposite side. There will also be a loading platform for motor trucks in connection with the shipping department for service to Detroit manufacturers. A spur of the new Pennsylvania road to Detroit will also enter the plant.

Cross Country Type Structural Rolling Mill

Electrically Driven Twenty-eight Inch Structural Mill at Tennessee Coal, Iron & Railroad Company, Fairfield Works, for Rolling I-Beams, Channels, Angles, Rounds and Flats.

THE TENNESSEE COAL IRON & R. R. CO. in their new plant at Fairfield Works, Birmingham, Ala., have recently installed what is perhaps one of the most modern structural mills in the country. It is of the cross country type.

The furnaces supplying this mill are of the side door hearth type, fired by oil and coke oven gas, and occupy a building running at right angles to the mill building. Part of these furnaces are used for supplying the new 110 inch plate mill and others are used for suplying the structural mill.

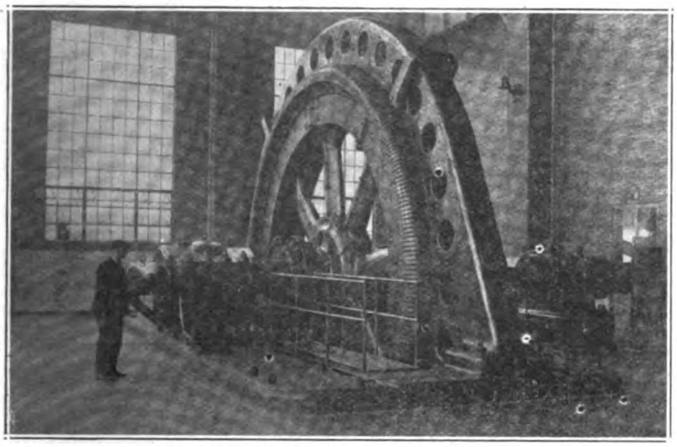


Fig. 1—General Electric motor drive on roughing rolls 2,500 hp, 82 rpm with breakable end thrust.

The first stand of this mill is three-high, 28 inch P. D., with rolls aproximately 66 inches long. It is driven by a General Electric motor, 2,500 hp, 82 rpm. The mill is served by a pair of tilting tables counterbalanced by the well known hydro-pneumatic system. One of the principal features of this stand consists of the automatic manipulation of the blooms on the table, this being accomplished by a specially designed manipulator and a series of easily adjustable switches.

After leaving the first stand, the material then passes to the second stand which is a two-high stand, 26 inches P. D. From there the material passes in a straight line to the third stand. After passing through this stand the material is transferred sidewise and passes through the fourth stand which is on the same train as the third stand. Both third and fourth stands are three-high housings which operate as two-high mills, the material making only one pass in each stand.

The fifth stand is of the three-high type, the material entering into the top pass, repeats back through the bottom pass from thence going directly into the finishing stand which is directly in line. This No. 6 or finishing stand is of the two-high type on 24 inch P. D. roll.

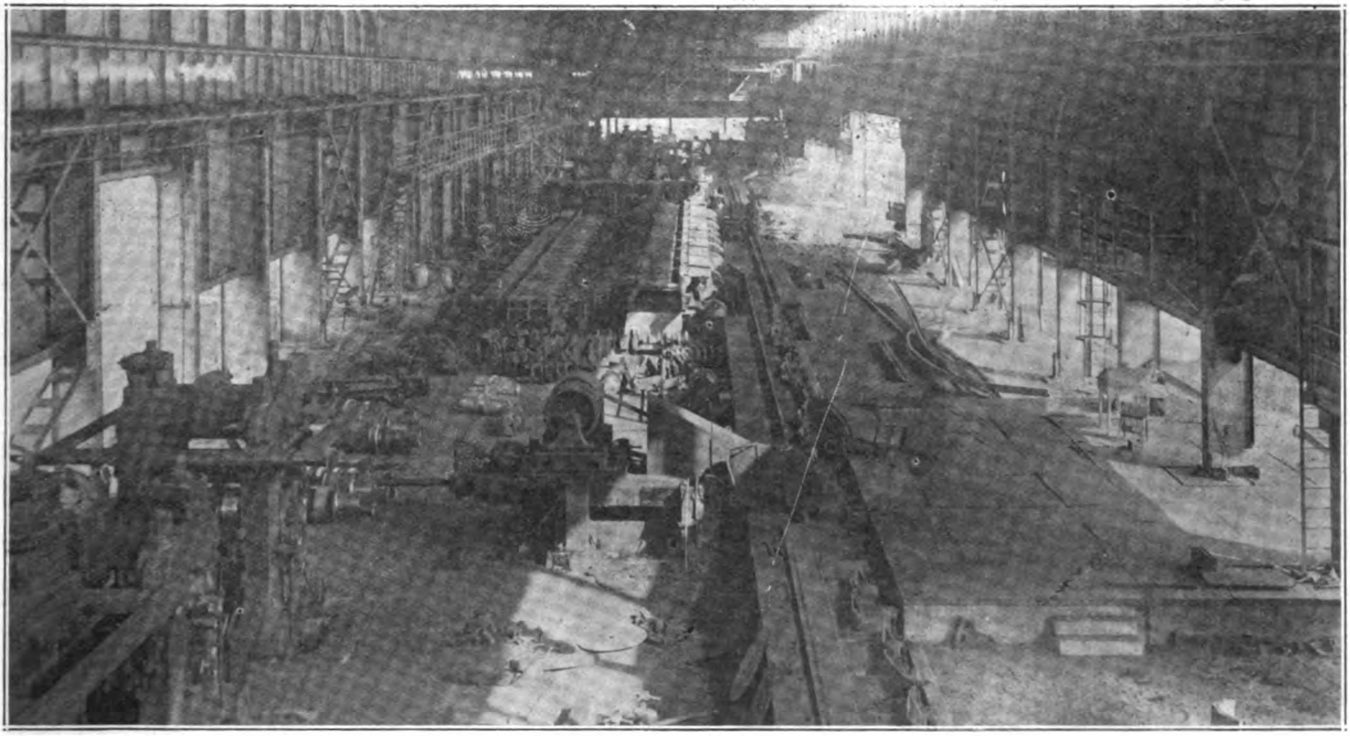


Fig. 2—View of structural mill looking from finishing stands toward furnaces.

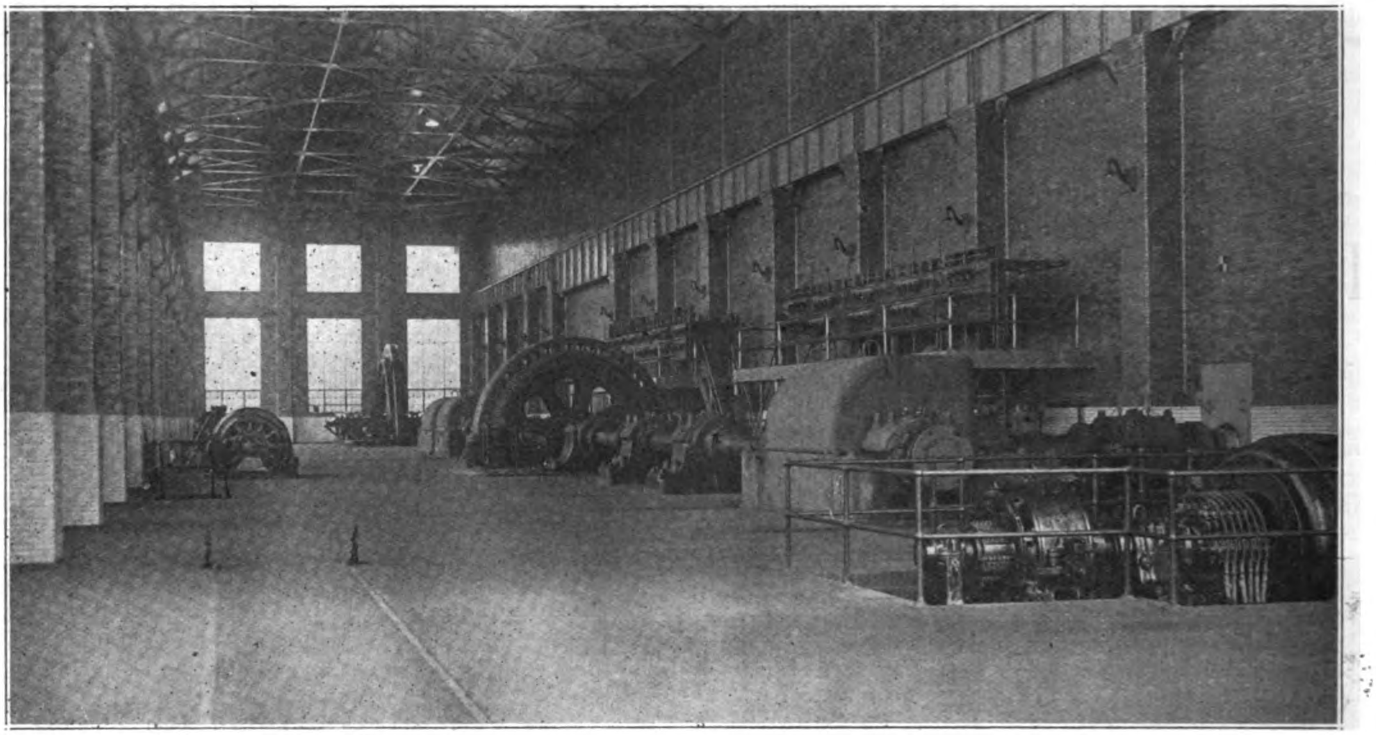


Fig. 3—Power house, showing motors for driving roughing stand in the distance. 3,000 hp motor for driving other stands shown in the center.

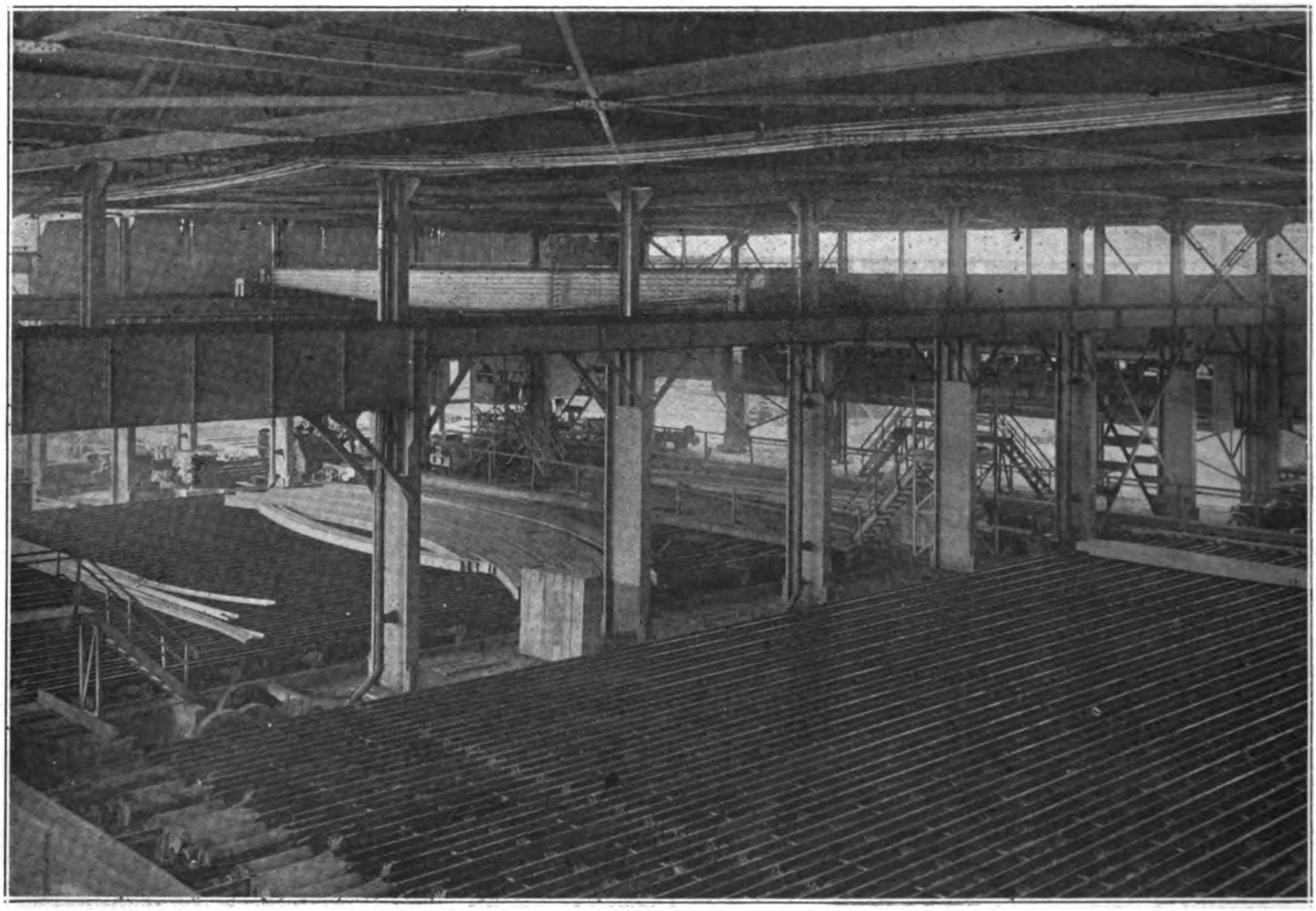


Fig. 4—View of cooling tables.

Stands No. 2, 3, 4 and 5, are driven by means of line shaft and bevel gears from a 3,000 hp General Electric motor running at 130 to 155 rpm. The bevel gear drive has no flywheel on it at the present time, but provision was made so that this could be added later if desired.

All of the roll stands are of the same general type, having cast steel housings. The pinion housings are of the most modern type, being entirely enclosed with helical cut teeth and journals running in bearings which are lubricated by a force feed oiling system.

Fig. 3 gives a view of the power house, the motor for the roughing stand being shown in the distance, the 3,000 hp motor drive for the other stands being shown in the middle of the picture.

The finishing stand is driven by a 1,000 hp Westinghouse motor through a gear set. This gear set was supplied by the Falk Manufacturing Company. On this mill all the roll stands complete with their fillings, etc., the bevel gear drive complete, the 28 inch roughing stand complete with tilting tables, automatic manipulator, etc., were designed and built by the United Engineering & Foundry Co., of Pittsburgh.

Fig. 2 shows a view of this mill looking from the finishing end towards the furnaces. The transfer back of stands three and four are plainly shown. Special attention was given in the arrangement of this mill for the rapid changing of rolls, this being accomplished by lifting out the roll housings, fillings, etc., and setting others in their places.

The mill is equiped with two finishing ends. The material after leaving the hot saw is fed through two modern roller straighteners and then taken to the cooling beds, one roller straightener serving each of the hotbeds.

The runout tables, hotbeds, etc., were designed and built under the supervision of the engineering staff of the Tennessee Coal, Iron & Railroad Co. The hot saws, cold saws, roller straighteners, gag presses, etc., were designed and built by the United Engineering & Foundry Co.

The products which can be rolled on this mill are aproximately as follows: I beams from 6 to 15 inches; channels from 7 to 15 inches; ship building channels 6x12 inches; bulb angles 7 to 10 inches; angles 3½x3½ to 8x8 inches; guide rounds 2 to 4 inches; flats 6 to 15 inches.

While the mill has been in operation only a short time, it already has demonstrated that it will exceed the expectations of the Tennessee Coal, Iron & Railroad management, both as to tonnage and operating cost.

Development of Modern Sheet Rolling

Equipment and Operations Peculiar to Manufacture of Sheets Outlined in Full—Sheet Mill Drives, Roughing and Finishing Mills, Character and Operation of Rolls, Process of Rolling.

By W. H. MELANEY,
National Roll & Foundry Co.

WHILE modern steel rolling has made wonderful progress over the conditions that were prevalent years ago, one of the strange features that attracts attention is that the actual principle and methods of rolling sheets have changed but little, and even the machinery used to produce the modern sheets differs but little from that used years ago, except in size and weight.

Drive for Sheet Mills.

It is true, of course, that the power used to drive sheet mills today differs radically from the old steam engine used in bygone years. The old process was to use a powerful, slow-speed engine connected to the mills through a gear or rope drive, which was afterwards very generally discarded for the direct connected engine drive, with an exceptionally heavy flywheel to take the very irregular load, and keep the mills running at a fair average speed of from 26 to 30 revolutions per minute. This was considered for a time the ideal drive for a sheet or tin mill.

But electrical engineers were at work all over the world developing electric motors, which they hoped would be able to do even this heretofore undreamed of task of driving roll trains, and the result is that today most of the mills are driven electrically.

This is accomplished either through gears which is the most generally used method, or through a rope drive where this sort of drive had been in use before. In either of these cases, a comparatively fast speed motor (compared to the old direct connected engine) is preferably geared by a single reduction gear direct to the mills, permitting mills to be driven on each side of the drive.

These mills have a uniform rotation, where sufficient power is used of about 30 rpm on standard 30-inch mills, and either alternating or direct current may be used, depending on which is best obtainable.

Modern practice has shown that too many mills should not be connected to one motor, as a stoppage of the motor from any cause would put too many mills out of commission, and thus produce too great a loss. Also if the mill next to the drive went out of commission, through the breaking of a roll, all the succeeding mills on that side of drive would also be down, so that it has become customary to put only from six to eight mills on one drive, usually arranging them half on each side of drive, so that if one side is down, through the breaking of a roll, or coupling box, the other side could still keep working.

Roughing Mills.

The average sheet mill unlike the tin mill is composed of two stands of two-high rolls, one on which the roughing down is done, and the other stand for finishing. On tin mills only one stand is used for both roughing and finishing. The roughing stand may be one of two types. One in which a balanced top roll is used, and where both top and bottom roll are driven through a separate stand of pinions, the top roll being balanced by weights and levers so that it is held up against the housing screws, and out of contact with the bottom roll. This will permit any thickness of slabs to be rolled. Or a jump roughing stand may be used on which the top roll is not balanced but is driven by friction from the bottom roll, and in which case it has to jump up against the slackened housing screws to permit the bars to enter the rolls. This type of roughing is seldom used where the bar to be rolled is more than an inch and a quarter thick.

In the balanced pinion driven roughing mill, a large hand wheel six or eight feet in diameter is connected through bevel gears to the housing screws in order to facilitate the operation of raising or lowering the top roll, while on a jump roughing mill it is customary to use a spanner wheel such as is used on the finishing mill in which a spanner bar fits into notches around the circumference of the spanner wheel, and extends down in front of the housing within easy reach of the operator, which will revolve the screw through a part of a revolution; the bar is then lifted and placed in another notch, and the operation continued. Of course, under this arrangement both spanner bars are connected together with a cross bar so that both the screws will move in unison.

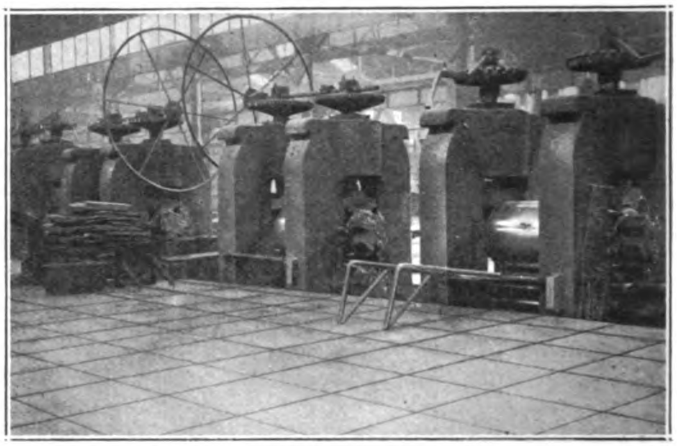
The author of this article describes modern sheet rolling practice in an interesting manner. The outstanding feature of sheet rolling is the fact that the practice and methods vary so little from that of the earlier mills. The only development during the past few years has been in the drives. Due to the great demand for sheets at the present it may be that some technical progress will take place in the future.

Finishing Mills.

The finishing stand is a two-high jump mill in which the top roll is driven by friction from the bottom roll, and a spanner wheel and spanner used to operate the screws. The question has often been asked, "why are only two-high rolls used in this work?" This is because where sheets are rolled in packs, that is three or more sheets placed one on top of the other, and of light gauge, it is absolutely essential that every part of the pack gets exactly the same amount of reduction and elongation, so that there is no tendency for the sheets to buckle in spots, thereby making it impossible to hold the sheets in position in the pack. It is apparent that if only two rolls are used, the pack in its various passes through these rolls will have practically the same contour of surface, even though that surface may not be entirely level and if any part of the pack is slightly thicker than another, it will remain so through to the finish.

But if three rolls are used, it would be impossible under the normal working conditions to keep their surface always alike and perhaps what would be the thicker spot on the pack in its passage through the bottom and middle roll might become the thinner spot on its passage through the middle and top roll, thus producing through a greater amount of reduction of the metal, greater elongation at this particular spot, than anywhere else on the pack. This elongation would produce a buckle, and eventually it would be impossible to have the sheets lie flat together. It would also cause the sheets to stick together in spots, and make it difficult to open or separate the pack after it has been sheared.

Another difficulty in using three rolls is that it would be next to impossible to keep the expansion ot the three rolls the same and this of itself would produce a difference in the surface of the pack on each pass.



Typical sheet mill.

Rolls.

The rolls used on the finishing mills are known to the trade as chilled rolls, that is, rolls in which the rolling surface is of a crystaline chilled structure, extending into the roll a distance of about three-quarters of an inch deep. This surface is extremely hard, similar to a hardened piece of tool steel, is steely white in color, while the balance of the roll through to its center is of a dark gray color, similar to any ordinary cast iron, and about as soft. This makes a very peculiar combination, and creates considerable trouble in hot rolling, as the expansion of the chilled structure is about double that of the soft gray center, and if permitted to heat up too rapidly, will tear the roll in two due to the difference in expansion of the two different structures.

One peculiarity of cast iron is that when heated it has a certain amount of permanent expansion. That is, it never contracts back to its original size, but remains slightly larger than it was before heating. This same condition happens each time it is heated and the grain becomes slightly more open in consequence and the greater the depth of chill, the greater the expansion. Now in practice, as the center of the roll gets hotter than the ends, the roll, when thoroughly heated, would be slightly larger in diameter at its center or convex in form. This is compensated for by turning either one or both rolls slightly concave, and the amount of concavity will depend primarily on the depth of chill the roll contains, (the greater the depth of chill the more concavity required) as well as on the number of times the roll has been heated. As its ability to expand decreases somewhat each time it is heated, and when it has been a long time in use, or the chill has been greatly reduced in depth, due to wear and turning, it has so little expansion that if it becomes a little too hollow or concave, it is almost impossible to work it hard enough to bring the center up to the diameter of the ends and then it is described as having "no pull or draw," and the ends of the pack become too crescent in shape, causing undue scrap and waste. Such rolls should have less concavity turned into them when they are dressed.

Warming Up Rolls.

Rolls, although massive in size, are so easily broken, due to their difference in expansion, that it becomes quite a problem to get them properly heated through ready to begin the turn's work, especially on Monday morning when the mills have all been filled with newly turned rolls, and there are many different ways of attaining this end. Most mills roll a few bars or scrap ends to gradually warm them up, never attempting to get full tonnage the first two or three hours after the mill starts. But the ideal method of warming up the rolls is to run hot water from a boiler directly over the surface of the rolls for several hours, with the rolls revolving slowly so that every part of the roll becomes warm through to its center before a bar is ever permitted to be rolled, and in the end this method is cheapest, because it cuts roll breakage to the minimum, and many rolls which break later on in the week, were in reality cracked in warming up and finally let go under pressure.

Once a roll has been thoroughly heated up until it has reached a temperature of 700 to 750 degrees F. in the center which is its hottest point, and the expansion has brought the surface of the two rolls in contact over practically their entire length of rolling face, the roll is in condition to finish the sheets with comparatively square ends, and if this temperature can be kept constant and not permitted to increase or decrease rapidly, there will be little danger of breaking the roll, even if more than the ordinary tonnage is rolled.

Neck lubrication, of course, is an important item as to this cause can be blamed most of the hot necks with resultant cracked fillets and finally the broken neck. It is also responsible for much of the gauging of bars, which later on results in a broken roll, and rolls are an expensive item in the production of sheets.

Rolling the Sheets.

Sheets as well as tinplate are rolled from sheet bars, which are usually 8 inches wide and from ⅜ to 1¼ inches thick, depending on the size and gauge of sheets to be rolled, and of a length slightly longer than the width of sheet to be produced, and are rolled crosswise in the rolls. That is, the width on 8 inch size of bar is gradually spread out until it becomes the length of the finished sheet, and the original length of the bar becomes the width of the sheet, thus changing the direction of grain of the steel at right angles to what it was in the sheet bar.

Two heating furnaces are used in the process. One is called the pair furnace, in which the sheet bars are heated, and the other the sheet furnace, in which the partly rolled sheets are reheated and rolled out to their finished size and gauge.

Two bars or a pair (hence the name), are drawn from the furnace at one time, shoved one after the other through the roughing rolls, and the catcher on the other side of the rolls, shoves them back over the top roll, and this process is repeated until they have been reduced in thickness to the necessary amount to enter the finishing rolls. This only requires two or three passes, then they are swung over to the finishing mill, one piece on each side of mill, so that when the roller shoves his piece into the rolls the catcher is shoving his piece over the top roll ready for the roller, and this continues for several passes until the pieces are thin enough to match together, when they are placed one on top of the other and passed through the rolls until the proper elongation is attained, then thrown onto the standing where the matcher strips them apart, rematches them, usually putting three sheets together, places them in the sheet furnace and reheats them repeating this operation until sheets have been rolled to length and gauge.

This is what is termed "single iron," but if light gauges are to be made when the pack of three sheets have been rolled to a proper length, the pack is doubled over on itself, and given one blow by a steam or air doubler hammer to flatten the pack, then reheated and rolled as a pack of six sheets, this is "doubled iron," and is used for common sheets or galvanizing.

Cold Rolling.

After the sheets are passed a number of times through the cold rolls to even up the slight roughness of their surface, they must be annealed.

Annealing.

The sheets are placed one on top of the other to a depth of two or more feet on a heavy cast steel annealing bottom, then covered completely over with a steel annealing box, and the joint luted with sand to prevent an excess of air being admitted, and placed in an annealing furnace and heated to about 1,500 degrees F. for hours, then allowed to cool slowly before the cover is removed. This gives the sheet an even blue gray color, and makes it soft and pliable, removing the hard brittle nature imparted to it by the cold rolling. The sheets are then ready for the market, if intended for common sheets. But where high class sheets are required, such as automobile sheets, a much more elaborate method of pickling, cold rolling and annealing is required.

Plate Mill Draft and Peak Load Relation

Screwdown and Wattmeter Readings Form Basis of Interesting Discussion of Draft and Peak Load Relations as Influenced by Steel Temperature and Number of Passes.

By J. T. EATON.

ELECTRIC drives on steel mills offer great possibility for investigation of the characteristics of power consumption in relation to the conditions at the rolls. The instruments included in the regular equipment of the switchboards and control apparatus are sufficient to obtain satisfactory data for studies along various lines. This may be done with the added advantage that it is unnecessary to make the investigations under test conditions and with permanent instruments sufficiently extensive observations may be made to insure reliability of conclusions.

The following discussion of plate mill drafts and their relation to the peak loads on the drive motor is based on observations of this kind and through familiarity with the operations of rolling plates. The mill is a 132 inch, three-high stand, operating at approximately 45.2 r.p.m., driven by a 5,000 horsepower ac motor and 60-ton flywheel running at 190 r.p.m The draft was recorded for each pass from the screwdown drum and the peak load was read from an indicating wattmeter. Observations of various sizes of slabs being rolled to different size and thickness of plates show that the following results

Slab No. 1

Pass No.	Screw Readings	Draft %	Peak Load K.W.	Ratio %/K.W.
1	8.54	5.1	600	.....
2	8.43	1.3	700	.....
Slab Turned				
3	7.69	8.8	750	.0117
4	6.96	9.5	950	.0100
5	6.25	10.2	1,150	.0089
6	5.47	12.5	1,400	.0089
7	4.84	11.5	1,400	.0082
8	4.25	12.2	1,600	.0076
9	3.67	13.7	1,700	.0080
10	3.15	14.2	1,800	.0079
11	2.52	20.0	2,300	.0087
12	2.06	22.3	2,400	.0093
13	1.59	22.8	2,900	.0079
14	1.25	21.4	3,000	.0071
15	1.05	16.0	2,900	.0055
16	.80	23.8	2,900	.0082
17	.67	16.3	2,800	.0058
18	.60	10.4	1,800	.0058
19	.55	8.3	1,900	.0044

Slab No. 4

Pass No.	Screw Readings	Draft %	Peak Load K.W.	Ratio %/K.W.
1	8.53	5.2	600	.....
2	8.44	1.1	700	.....
Slab Turned				
3	7.75	8.2	700	.0117
4	6.91	10.8	900	.0120
5	6.20	10.3	1,300	.0079
6	5.50	11.3	1,500	.0075
7	4.71	14.4	2,000	.0072
8	4.07	13.6	2,000	.0068
9	3.48	14.5	2,100	.0069
10	2.96	14.9	2,000	.0074
11	2.52	14.8	2,100	.0070
12	2.01	20.2	2,500	.0081
13	1.55	22.9	3,100	.0074
14	1.25	19.4	3,100	.0063
15	1.00	20.0	3,000	.0066
16	.82	18.0	2,800	.0064
17	.71	13.4	2,500	.0054
18	.64	9.9	2,000	.0049
19	.54	15.6	2,100	.0074
20	.53	1.9	1,550	.0012

Slab No. 7

Pass No.	Screw Readings	Draft %	Peak Load K.W.	Ratio %/K.W.
1	8.54	5.1	700	.....
2	8.46	0.9	700	.....
Slab Turned				
3	7.76	8.3	1,100	.0064
4	7.00	9.8	900	.0109
5	6.37	9.0	1,100	.0082
6	5.76	9.6	1,100	.0087
7	5.22	9.4	1,400	.0067
8	4.76	8.8	1,600	.0055
9	4.21	11.6	1,900	.0061
10	3.66	13.1	2,000	.0065
11	3.20	12.6	2,100	.0060
12	2.71	15.3	2,500	.0061
13	2.21	18.4	3,000	.0061
14	1.75	20.8	3,150	.0066
15	1.40	20.0	2,900	.0069
16	1.20	14.3	2,900	.0049
17	1.00	16.7	2,800	.0060
18	.84	16.0	2,900	.0055
19	.69	17.8	2,300	.0077
20	.61	11.6	2,200	.0053
21	.55	9.8	1,700	.0058

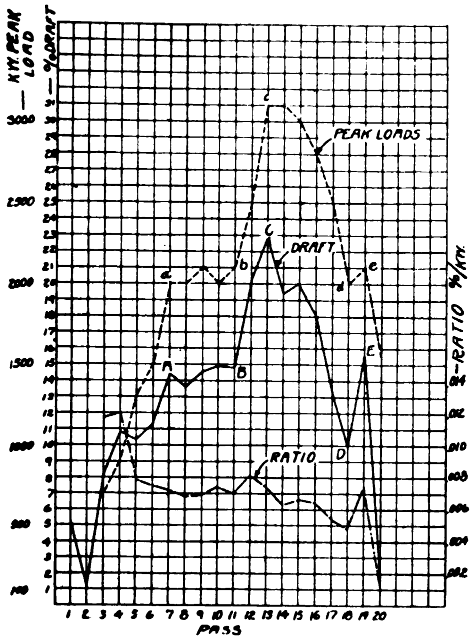


Fig. 1.

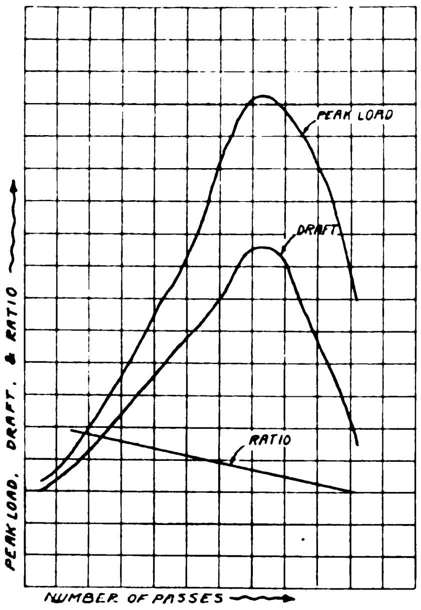


Fig. 2.

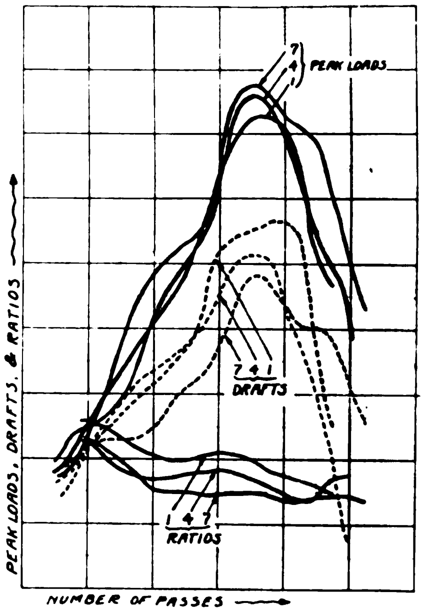


Fig. 3.

apply to all sizes and gages in the normal range of the mill and further discussion will be limited to a group of slabs of the same size being rolled to the same size plate. This is done to point out facts concerning the temperature of the steel and the number of passes required, which can only be done by comparing duplicates.

The accompanying table is taken from three slabs 9 x 22 x 74 inches, each weighing 5,250 pounds, being rolled to a plate 76 inches wide finished, and 17/32-inch in thickness. The column marked "screw readings" gives the distance between the rolls for each pass, which is the thickness of the steel as it leaves the rolls. The drafts are figured directly from the readings of the screw as customary in plate mill work without regard as to the possible effect of side spread on the cross-sectional area leaving the rolls. Side spreading occurs in rolling plates only in the first few passes on thick slabs and then to a negligible extent. The ratio of per cent/kw. is taken as a simple means of representing the relation between the draft and peak load of an individual pass. The variation of this ratio with the successive passes is the object of this study. It is obvious that for a given pass and draft the power consumption will decrease as this ratio increases. In the table the ratios are not given for the first two passes for the reason that the slabs were rolled lengthwise in these two passes and the ratios are not to be compared with those that follow because the width of the steel going through the rolls is not the same.

The method of rolling used on these particular slabs follows: Two passes, one heavy and one light were sufficient to elongate the slab to the width of plate ordered plus side scrap allowance. The slab was then turned through 90 degrees and rolled to the gauge of the plate required in a direction transverse to the direction it was rolled on the blooming mill.

The curve in Fig. 1 shows the values of draft, peak load, and ratio of draft to peak load plotted as ordinates with the number of the pass as abscissa for slab No. 4. The number of the pass may be considered as approximately proportional to the time as the operations of the tilting tables are steady and the extra manipulation with hoops in the roughing passes about compensate for the additional time the steel is in the rolls during the finishing passes.

In the roughing passes the draft is limited by the small entering angle at which the smooth rolls will take the steel. The draft increases as the thickness of the steel decreases until the strength of the mill or driving power prohibit further increase in the percentage of reduction. The draft is maintained high for a few passes and is then decreased owing to the reduced temperature of the steel and the increased resistance to deformation. The finishing pass is light. These general practices in drafting plates are borne out by the data and draft curve of slab No. 4 as shown in Fig. 1. The irregularity at the point D, the eighteenth pass, comes from the fact that the table operator entered the plate into the mill before the screw oprator had time to advance the screw to the proper position. This happens frequently in fast rolling.

Examination of the curve of peak loads in connection with the curve of drafts shows that the peak load changes have the same general tendency as the draft changes. The inflections, A, B. C. D, E, of the draft curve have the corresponding inflections a, b, c, d, e of the peak load curve. These inflections indicate that the peak load is very sensitive to the effect of increased or decreased draft. The curve of ratio of draft to peak load also shows an effect of sharp changes in the line of drafts. This is because the flywheel equalizes the load to such an extent that the peak loads do not respond fully to abrupt changes of the line of drafts. This leads to the conclusion that with the effects of the flywheel eliminated the ratio of draft to peak load would be more uniform and the curve of the ratio would follow a straight line. Portions of the ratio curve where the drafting has been regular show the same tendency toward a straight line. Curves of slabs upon which the drafting was more regular show the straight line tendency to a much more marked extent than Fig. 1. The curves of Fig. 2 are compositions made from a number of curves similar to Fig. 1. This was accomplished by plotting on thin paper and causing a strong light to shine through a number of sheets placed on top of each other with coördinates matched. A straight line is used for the ratio curve drawn with the average slope of the ratio curves of this particular group of slabs.

The downward slope of the ratio curve indicates that the reductions in thickness of the steel in the latter passes are made at a greater power cost than the beginning passes. A reduction of 0.05-inch near the finish of a plate will often require one pass whereas the same amount added to the reduction of the third or fourth pass will be made with a slightly increased draft and a corresponding slight increase in the power consumption of the pass. Hence, to make the power cost of rolling a minimum, attention should be given to drafting to the limit in the roughing passes. No rules can be layed down how far this can be carried. The experience and judgment of the operator brought into action by an incentive form the only means of progress toward improved practice in this direction.

Attention will now be turned to the effects of various degrees of heating of the steel. The slabs for which the data is given in the table were taken from a series drawn from a continuous heating furnace, in succession as rapidly as they could be rolled. This was faster than slabs of this size can be brought to rolling temperature in one furnace. Slab No. 1 was drawn after being allowed to lie in the hottest part of the furnace for a time. No. 4 being farther back did not become so hot before coming to the rolls and required one more pass to finish than No. 1. Slab No. 7 came forward through the hottest part of the furnace still more rapidly and came to the rolls with less heat. No. 7 required two more passes than No. 1, and was the last to be drawn from that furnace till time was allowed for the temperature of the steel to rise. Fig. 3 shows the curves of draft, peak loads, and ratios plotted together for comparison. The irregularities of these curves have been worked out by a process of graphical averaging to facilitate the comparison. This method is resorted to for the purpose of availing the maze that would result from plotting the curves accurately on the same coördinates. Data on the actual temperature of the steel would be more assuring to some readers, but it is sufficient for the purposes of this paper to note that 10 per cent addition to the required number of passes and a substantial increase in the power requirements of the finishing passes are the results of insufficient heating.

Examination of the draft curves of Fig. 3 shows that heavier drafts were allowable with the hotter steel and that the low loads were obtained on the slab that was drafted most heavily. The ratio curves show clearly the advantage of hot steel over steel that is just hot enough to roll from the standpoint of power consumption.

In conclusion it is desirable to call attention to the fact that the slope of the ratio curve and the general tendencies of the draft and peak load curves will not be exactly the same for all mills or work of different sizes. The flywheel effect, the size of the rolls, the width of plate being worked, and many more considerations produce variation that cannot be covered in this paper. However the author has made sufficient observations under wide variation of the conditions mentioned to give assurance that the relations pointed out hold in all but extreme cases.

Electrical Equipment for Reversing Mill

Reversing Blooming Mill Electrical Equipment Shipped to the Imperial Steel Works of Japan—To Be First Electrically-Driven Blooming Mill in Far East.

SEVENTEEN carloads of electrical equipment for steel mill operation, are now being delivered for installation with what will be the first electrically-driven blooming mill to be erected in the Far East. This equipment is to replace a steam engine now operating a 40-inch reversing mill.

The mill will form a part of the plant of the Imperial Steel Works of Japan located near Tokio, and the electrical apparatus is being furnished by the Westinghouse Electric & Manufacturing Co. of East Pittsburgh, Pa.

The blooming mill in question will be capable of rolling steel ingots measuring 500x500 millimeters and weighing 3,000 kilograms normal or 5,000 kilograms maximum. The capacity will be 50 tons per hour.

The mill will be operated by a 3,500 hp single unit motor, of the reversing blooming mill type, taking direct-current power at a voltage of 600 and operating with a speed of 8 to 100 rpm. To supply power to the motor a flywheel motor generator set is being furnished. The generator is of 2,800 kw capacity, 600 volts, dc, 368 rpm. It will be connected in series with the reversing motor and is designed to stand the same momentary current peaks as the reversing motor. The generator is driven by a 2,500 hp, 8-pole alternating current motor of the wound rotor induction type taking power at 3,400 volts, three-phase, 25 cycles and operating at a speed of 368 rpm. A slip regulator is used to control this set.

A notable feature of the motor generator set is a 75,000 pound cast steel flywheel measuring 14 feet 9 inches in diameter.

For field excitation, there is being furnished a motor-driven exciter set consisting of one 32½ kw 125 volt constant potential exciter, one 12½ kw 125 volt variable potential exciter and a 70 hp three-phase, 25 cycle, 220 volt driving motor, all direct connected and mounted on a common bed plate.

Accessories used with the foregoing equipment are a Sirocco blower driven by a 40 hp three-phase, 25 cycle, 220 volt squirrel cage induction motor; an air washer to be used in connection with the blower; and a 125 kva 3,400/220 volts, three-phase, 25 cycle transformer connected high voltage side in star, and low voltage side in delta, to supply power for the exciter set and blower motor.

Another part of the shipment comprises switchboard panels containing instruments, switches, circuit breakers, shunts and relays for the control of the motors, generators, and feeders. Additional equipment includes disconnecting switches, oil circuit breakers, and current transformers to be mounted on pipe framing.

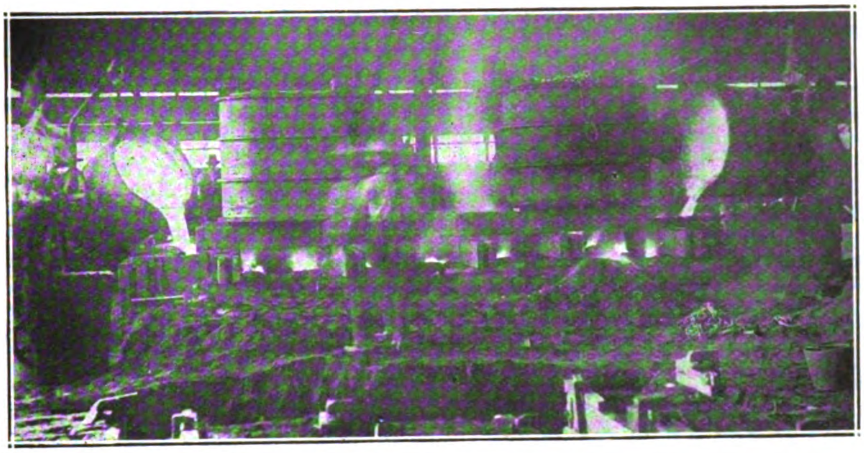
This equipment, when installed, will notably exemplify the successful progress that has been attained in applying electric power to the operation of steel mills.

Some time ago an investigation concerning the Japanese iron and steel industry was made, which was published in the February, 1919, issue of THE BLAST FURNACE AND STEEL PLANT. The following taken from this article is of interest:

The report gave statistics showing the increased consumption of iron in Japanese manufactures as compared with the output and they then contrast Japan's output and iron manufactures with those of other nations. Their figures are largely taken from a report of the Iron Foundry Investigation Society and are undoubtedly sufficiently disconcerting to those Japanese who believe thta all civilizations, and particularly their civilization, power, prosperity and prestige, are founded upon mining and metals.

It is argued, for instance, that since the demand for pig iron increased from 59,996 tons in 1903 to 224,309 tons in 1913, the demand, which has been growing proportionately, would be 360,000 tons last year and 533,800 tons in 1923. The demand for steel in 1903 was 286,479 tons and in 1913, 748,056 tons; while the estimated demand for this year will be 1,113,086 tons, and in 1923, 1,568,000. These figures do not include the tonnage of imported steel manufactures such as ships, machinery, railway cars and engines which formerly averaged about 92,000 tons a year. It is believed that including manufactured imports the demand for steel in Japan will be 2,193,000 tons in 1923.

Steel Foundry Department



THE steel castings industry has just passed through a very trying year. The sudden change from war activities to peace times left the foundries in a precarious position. This was of course also true of many industries, although the special nature of foundry work made it more difficult to suddenly change the nature of the product.

During the past year the quality of steel castings have been improved. This was particularly noticeable in the appearance of the castings. While the exacting specifications of ordnance work, during the war, required closer attention than ever before to annealing, physical tests, etc., there had been a noticeable but unavoidable deterioration in appearance of most of the steel castings. This was due to the excessive pressure behind production and due to the extreme difficulty of securing competent labor. However, during the last year this condition had been somewhat improved.

Years Progress in Steel Casting Industry

Lessened Demands for Production, Due to Post-War Conditions, Permit of More Attention to Quality in Steel Castings—New and Fruitful Investigations Started and Improvements Instituted.

By R. A. BULL.
Vice President, Duquesne Steel Foundry Company.

A RESUME of the conditions affecting the manufacture of steel castings during the year just closed is a chronicle of an unprecedented state of affairs. It is probably safe to say that in 1919 no industry has suffered more than that discussed here, except those industries which were created or greatly increased as a direct necessity of participation in the world war. These war industries in the main, erected plants which were temporary in their construction or capable of adaptation to other uses, and from the beginning kept in mind the ultimate cessation of hostilities and the consequent collapse of their wartime business. They were financed and engineered accordingly. In the steel foundry industry however, we have the disturbing picture of an industrial giant whose activities are no less essential to commercial progress in peace, than to military success in war, and whom the ending of hostilities left without means of support, other than resources wisely conserved against hard times.

The curtailment of output and the necessary enforcement of economy to reduce operating losses to the minimum, have resulted in many fruitful investigations into more efficient production, especially the elimination of waste in labor and materials. Comprehensive studies have been made looking to the more economical handling of work, including the reduction of "back-lash" operations.

During the war, the steel founders undertook their share of the industrial burdens of the nation, many obligating themselves for the manufacture of castings for war purposes, with which they had previously been wholly unfamiliar. Much of this work was extremely difficult to make and lack of familiarity with it imposed a serious handicap on the amateur producer. Gradually the steel foundries undertook to make many classes of castings of this special character, while devoting the balance of their product to work equally important to the government. As a result shop methods were upset and troubles multiplied. When the peak of the load had been reached in these respects, due to the most urgent pressure for production ever felt in the industry, the signing of the armistice came, bringing cancellations by the wholesale.

Consider here what had been before the war, the main support of the industry. The writer has seen no reliable statistics indicating what percentage of the total tonnage of steel castings normally goes into railroad equipment or serves other industries manufacturing such equipment. The sum total of the peace time tonnages directly and indirectly required for the construction and maintenance of our railroad systems is tremendous, probably representing much more than 75 per cent of the combined output of the steel foundries of the United States.

The cancellation of war orders and the increasing deficit of the Railroad Administration, with the consequent sharp curtailment of railroad purchases left this industry without an adequate peace-time channel through which to steer it past the troublesome reconstruction period of 1919. Meanwhile, prices of pig iron, scrap and the alloys customarily used in steel manufacture declined, some of them in great degree, leaving the average steel foundry with large stocks of raw materials on hand purchased at war-time prices. The resulting situation was particularly trying and made worse through the handicap imposed upon all manufacturing lines by the high cost of living and the unrest of labor. The year 1919 will probably be remembered in the history of the industry as the most unsatisfactory one ever experienced, considered apart from its preceding period.

Notwithstanding the losses sustained, benefits have accrued, and it is more helpful to dwell on these, than to elaborate concerning the trials, through which we have passed. The curtailment of output and the necessary enforcement of economy to reduce operating losses to the minimum, have resulted in many fruitful investigations into more efficient production, especially the elimination of waste in labor and materials. Comprehensive studies have been made looking to the more economical handling of work, including the reduction of "back-lash" operations—those which call for frequent passages over the same route—of raw materials and product. Neither the financial nor the labor situation has enabled many steel foundries to put into full effect reconstruction programs planned. Some of them are under way and others will be undertaken in the near future. The effect of all these will not only work for economy, but for the betterment of the product.

Purchasers of steel castings during the past year have remarked on an improvement in appearance. While the exacting specifications of ordnance work required closer attention than ever before to annealing, physical tests, etc., there had been a noticeable but unavoidable deterioration in appearance of most of the steel castings shipped. This was due to excessive pressure behind production and to the extreme difficulty of securing competent labor. The beginning of the year 1919 saw in most districts a surplus of skilled foundry labor for the amount of work to be done, although there has been a shortage of common labor in the industry throughout the period of depression. Steel manufacturers had now the opportunity—for some time denied them—to require proper care on the part of moulders, coremakers, chippers and other classes of skilled and semi-skilled labor whose combination of efforts is necessary to produce satisfactory castings. The time required to do good work has been expended, and better looking castings have been shipped this year than in 1918.

Fortunately for the industry, there has been an appreciable tonnage of steel castings produced this year for shipment abroad. This work usually requires inspection by foreign representatives, whose ideas are some times at variance with those of the average domestic inspector. This has had its effect in the more thorough cleaning of steel castings in general. And it is not improbable that a happy medium will be found establishing new cleaning room standards in American foundries which will amount to a compromise between inadequate regard for appearance, and the excessive attention to this factor, which has been customary in Europe. The need for education along this line does not rest solely with the producer. The consumer can get what he wants if he is willing to pay for it, and must concede that it is fair for him to bear his part of the burden imposed by extra labor involved.

Many steel foundries learned in 1918 that their annealing methods were inefficient. The exactions of ordnance work demonstrated this, as perhaps no other one thing could have done. It is useless to deny that annealing methods in the American steel casting industry in the past, have in general, been crude. It is proper to affirm that there has been a marked improvement in this respect during this year following the attention directed thereto in 1917 and 1918. It had been found that many annealing ovens were poorly designed, yielding an uneven distribution of heat. Much investigation has been instituted into the matter of annealing, and the research work which is yet being conducted will materially advance the industry in the future. There has been much guesswork in the past as to the structural changes which occur in the heart of a large mass of steel, such as a heavy roll, under heat treatment. Annealing schedules in many plants have been based on speculation, and not established as a result of actual determination. Usually, such schedules were maintained until the fracture of a large casting in service demonstrated that it was improperly annealed. The problem of determining the time required in raising the temperature of a heavy mass of steel to the critical point, in maintaining the maximum temperature for the proper period to permit thorough soaking, in reducing the temperature to normal at a speed which does not injuriously affect the casting, is by no means one to be lightly regarded, and calls for elaborate experimentation which is now being conducted.

For years there has been prejudice in the minds of many engineers against percentages of phosphorus and sulphur above .05 per cent in steel castings, as in certain other steel commodities. The difficulties experienced during the war in securing pure raw materials, compelled a modification of these limitations among many users, the American Society for Testing Materials being sponsor for the temporary adjustment to meet market conditions. Some steel founders had conscientiously maintained that the limitations imposed were based on speculation and not on fact, and felt that certain stipulations in current specifications had only the effect of increasing the price of steel castings to the consumer through the use of more costly raw materials. Recent stimulation of interest in engineering circles in this matter has had the beneficial effect of investigations to ascertain the facts. The most important of these researches is that undertaken by the American Society for Testing Materials, whose committee will announce the data it is collecting at the next annual meeting of that organization. It is probable that considerable light will be thrown on the subject. Those who make steel castings can be fairly credited with a sincere desire to know and to have published any conclusive information which will confirm or disprove the impression that a steel casting containing a slightly higher percentage of phosphorus or sulphur than .05 per cent has appreciably greater tendencies to fail under stress than one made according to the old limitations. Prejudice without substantiation in reference to such questions is unscientific, and like Prussianism is out of date.

The steel foundries have been fortunate in securing an appreciable amount of foreign business during the past year.

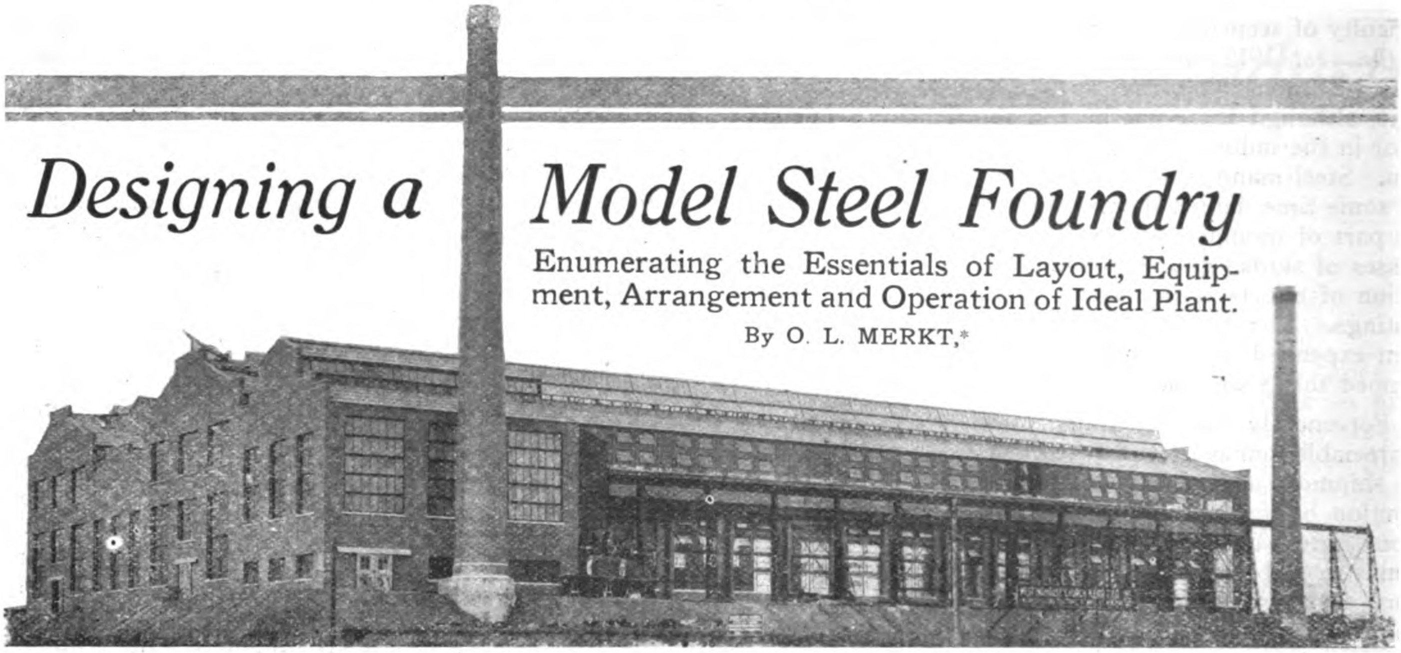
This foreign business has had its effect in being responsible for the more thorough cleaning of steel castings. This foreign-work has its drawback in that it usually requires inspection by foreign representatives, whose ideas are sometimes at variance with those of the average domestic inspector.

One cannot discuss the state of the industry as it has existed for this year without commenting upon the optimistic prospects for the future. The urgent need of equipment for the railway systems, the approaching return of the roads to private ownership, the unmistakably hopeful tendencies, recently manifested, of many large consumers of steel castings afford much encouragement to those whose time and labor are invested in the business of making steel castings. Nineteen hundred and twenty promises to be a good year for the industry, in contrast with the year now closing, in which has been produced probably not more than 40 per cent of the tonnage which would be considered the total rated capacity of the steel foundries of the United States. For these encouraging prospects we are indeed thankful. And for the lessons we have learned during the war and throughout this trying year of reconstruction we are undoubtedly wiser.

Designing a Model Steel Foundry

Enumerating the Essentials of Layout, Equipment, Arrangement and Operation of Ideal Plant.

By O. L. MERKT,*



THE remarkable growth of the steel casting industry in the past few years has brought to big manufacturers in general, and foundry managers in particular, the added burden of supplying the increased demands in the face of changing industrial conditions. Competition, labor scarcity, and other governing elements in the various manufacturing departments of the plant are accentuated in the foundry, especially when this department is supplying steel castings.

In the designing and arranging of the steel foundry the essential predominating factors must be given more than the usual careful study. Proper location, shipping and receiving facilities, possible future extensions, kind of castings, and daily or monthly tonnage must be considered with the type, class, and source of labor obtainable in order that the best economy of operation may be obtained.

As the electric steel and open hearth foundries are operated practically 24 hours per day, the problems of clearing floors, casting and shaking out with the least amount of manual labor and proper routing of materials are prime factors. The problems presented in the design of an open hearth foundry are almost identical with those of the electric steel foundry, insofar as general

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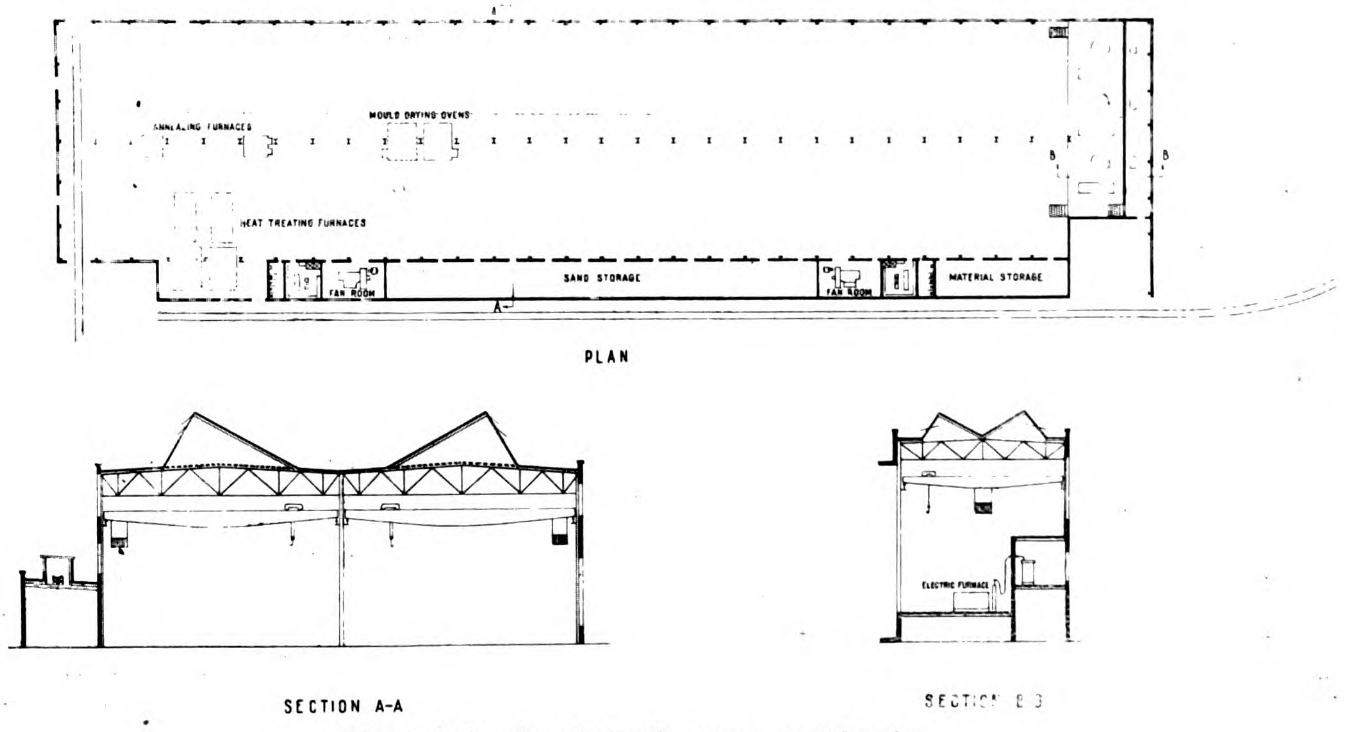
* Engineer, Westinghouse, Church, Kerr & Co., Inc.



Plan and elevation of electric furnace steel foundry.

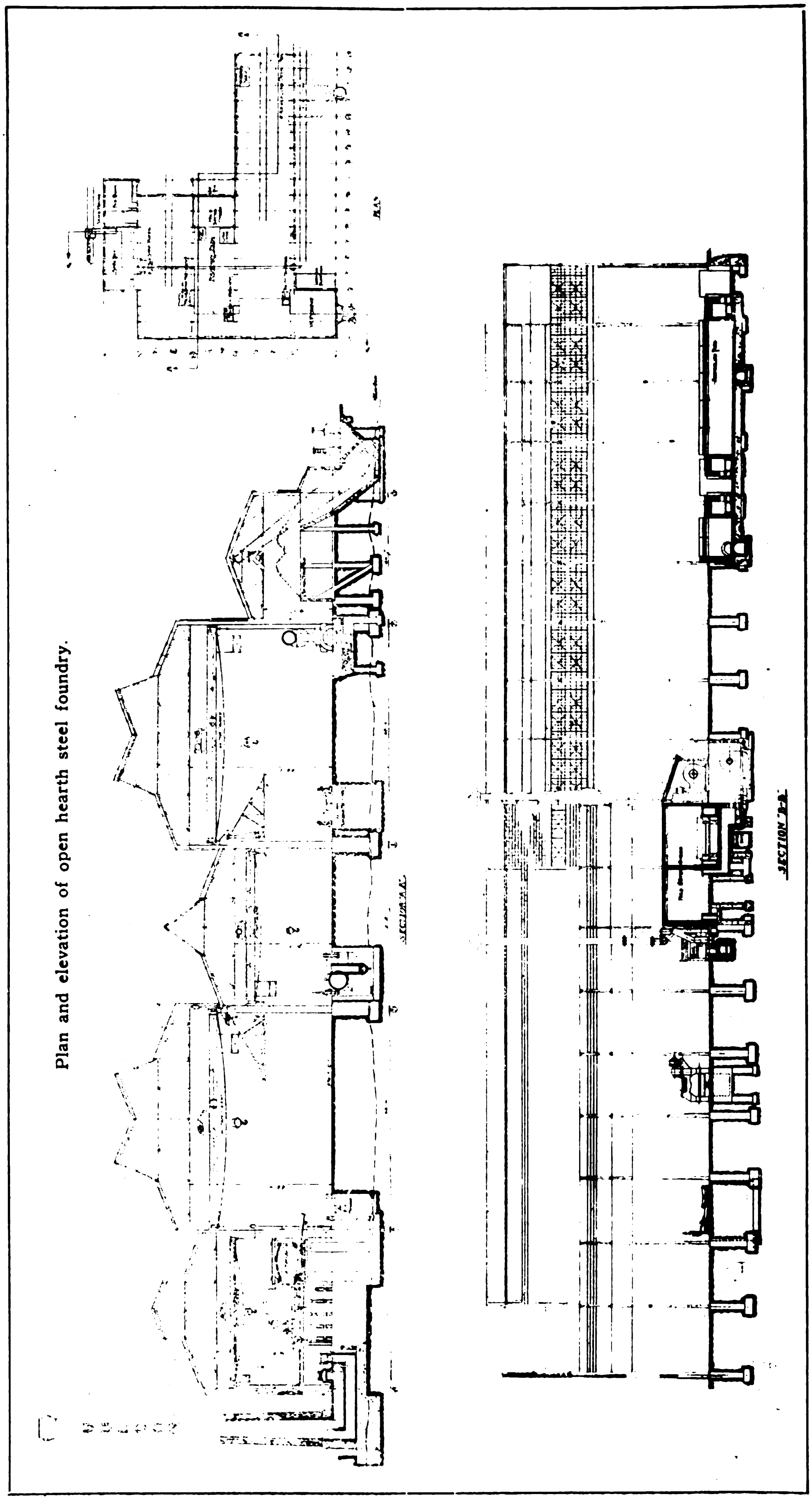
arrangements are concerned, depending upon the capacity of the plant.

Having decided upon the proper location and size of the various floors based on the tonnage requirements and the class of castings manufactured, the furnace should be placed so that scrap, pig iron, alloys, and other furnace material may be conveniently stored, and where they can be handled from storage to charging floor preferably by mechanical means.

As most of the work in the open hearth foundry is dry sand moulding, the relation of the casting floor, moulding floor and dry ovens should be such that a thorough type of dry oven can be installed. This permits the moulds to be passed into the dry ovens, clearing the moulding floor for continuous moulding. The completed moulds can then be set out direct from the dry oven to the casting floor ready for the heat. Green sand and snap flask moulding should be done on a floor adjacent to the casting floor and if possible in such a way that the green sand moulds need not be moved in preparation for the heat.

The arrangement best adapted for this practice is the use of three or more parallel bays; one side containing the moulding floor with sand storage bins adjacent, the center bay for the dry oven, core rooms and green sand moulding, and the opposite bay for the casting, shaking out and cleaning floors. Crane service in these bays with the addition of traveling wall cranes along the inside columns, makes the problem of handling moulds, shaking out, disposing of foundry refuse, etc., simple and efficient.

The floors for shaking out and cleaning can be located in the same bay, adjacent to the furnace house, permitting the ready handling and shaking out of the moulds and the return of the flasks to the moulding floor. In a great many instances it is found desirable to provide the center bay, part of the distance, with a mezzanine



Plan and elevation of open hearth steel foundry.

floor to allow for storing live flasks without interfering with the foundry operation.

In the above arrangements, the castings travel in a straight line to the cleaning, machining and shipping departments without any retrograde movements. The annealing furnace or pits should be located conveniently to the cleaning floor, preferably in such a way that the annealing is done after the moulds have been shaken out and the core refuse disposed of. The product can then be sent direct to the cleaning and machining departments where the proper grinding, chipping, and machining operations are carried on.

Considerable study should be given to the cleaning and machinery departments. This floor should be of ample size, as operation requires as much, if not more, space than the moulding and casting floors combined. In a great many instances it is found desirable to locate the cleaning and moulding departments in a separate building adjacent to the foundry proper, so that after the moulds have been shaken out, castings are taken into the cleaning buildings to be prepared for shipping. The use of a separate building for the cleaning department is dependent to a great extent on the relation of the foundry to the remaining plant, the size of castings, and the amount of preliminary machinery required before being placed in the manufacturing departments.

In very few open hearth foundries has any serious concern been given to the heating and ventilating facilities, most of the buildings having been designed with a view to natural ventilation. Natural ventilation for an open hearth foundry is at best unsatisfactory, and where a new plant is contemplated the proper provision should be made for mechanical ventilation, combined with the required heating.

The new open hearth foundry of the Vulcan Iron Works, at Wilkes-Barre, Pa., recently designed and constructed by Westinghouse, Church Kerr & Co., is a good example of the modern type of open hearth foundry. It will be noted that the building is L-shaped and permits the moulds to travel from the moulding floor from the dry ovens direct to the casting floor. After the heat is taken off, the casting travels in a straight line to the cleaning department. In this particular layout the annealing pits are located in the farther end of the cleaning floor. This has been done so that when the building is extended in the future the annealing equipment will be in the proper location to the cleaning and machining departments to take care of the increased capacity.

In the design and construction of a new open hearth foundry in conjunction with an existing plant or where an existing building is altered for open hearth foundry requirements, it is in most cases impossible to obtain an ideal layout, although after careful study the results may compare favorably with the most economical foundry layout.

Notes on the Manufacture of Steel Rolls

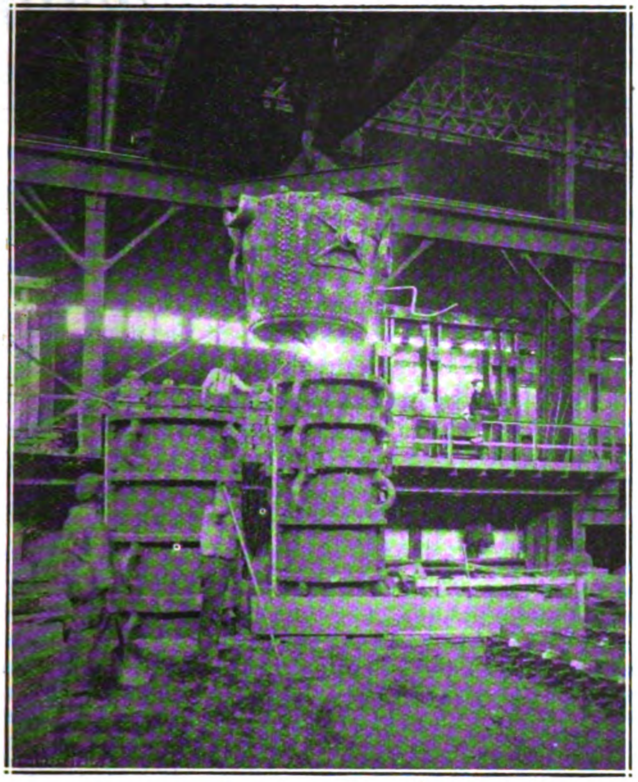
Some of the Difficulties in the Manufacture of Steel Rolls Are Pointed Out and Some Suggestions as to Their Proper Use Are Made.

When we look at the cast steel roll in all its massiveness and its simple lines of contour, we are wont to classify it as a simple casting. To produce a cast steel roll to meet the exacting demands of the rolling mill man is quite some undertaking, mass and simplicity of design notwithstanding.

There seems to be a variance of opinion among mill men as to the required or satisfactory chemical composition of a cast steel roll, with special reference to the carbon content. The variation in the carbon content oftentimes causes the steel to vary from almost a medium hard steel up to a spring steel constituency. This variance in all probability is due to a desire to eliminate too frequent "dressings" by specifying higher carbon content, thereby reducing roll surface wear.

The mold proper is usually made by using a sweep. The mold then must be thoroughly dried so that none of the mould wall may spawl off under the influence of temperature of the roll mass, resulting in sand spots or indentations on the roll surface. That the roll surface may be smooth and free from imperfections is obviously essential, for these defects would otherwise manifest themselves in the rolled product. In order that the mould may be properly filled and in order that a resulting freedom from seams and laminations may be avoided, the design, size and location of the gate or gates must be given due consideration, as must also the temperature at which the metal is poured. There is a great tendency to pour large masses at excessive temperatures. This practice has a deleterious effect in addition to causing undue shrinkage and segregation. Surface defects such as sand spots, porosity, etc., may also be attributed to this practise. In addition to a correct pouring temperature and in order that the roll casting may be free from segregation and undue shrinkage the "head or riser" must be so designed as to be of proper diameter, height and weight to assure a sound casting.

Even though the life of a cast steel roll for many purposes is far greater than that of the cast iron roll by virtue of its chemical analysis, nevertheless it must be further safeguarded so as to be able to meet the high production demands of modern rolling mill performance by being thoroughly annealed at a temperature in keeping with its chemical composition. A bit of rolling mill performance which possibly plays more havoc with rolls than any other one single thing, aside from improper design, is the feeding through the rolls of under-heated ingots, blooms and billets, the bending or buckling stress being so great as to oftentimes cause a roll of large diameter to break. These



Casting large steel roll.

strains are most apparent in the longer rolls In plate rolls this oftentimes is perceptible in the finished product, the thickness of the plate in the center being greater than at the edges

Oftentimes rolling mills are desirous of rolling sections outside and beyond the existing mill size classifications To satisfy this desire they very often introduce into existing mills rolls of larger diameter, thereby throwing out of proportion the ratio between the roll diameter and neck diameter, the latter diameter of which must necessarily remain constant. Under this new condition increased and undue stress are placed upon these rolls, oftentimes resulting in roll breakages, quality and solidity of casting notwithstanding.

To meet the continued demand of rolls of longer life, capable of withstanding rolling mill performance, demands of desirable surface, and not requiring to be dressed as often, there have been placed on the market within the past few years several brands of alloy rolls. The composition of these rolls are as varied as there are number of makers. Strictly speaking, they are not a cast steel roll, inasmuch as the carbon constituency is well in excess of the usual carbon range and also they may not be called a cast iron roll, inasmuch as the carbon constituency is considerably lower than that of average cast iron rolls.

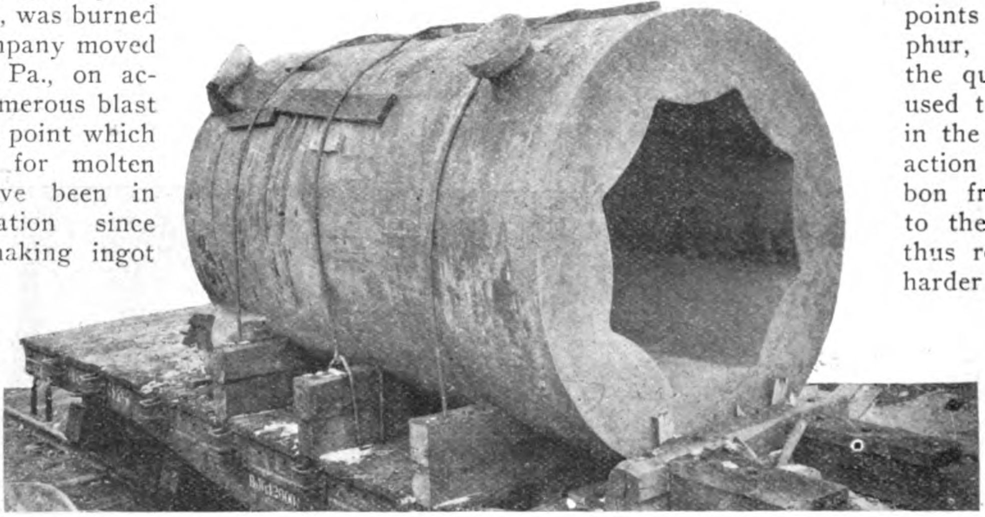
Grinding and chipping department where rolls are cleaned up.

Direct Metal Ingot Mould Manufacture

Specialized Knowledge and Experience Required to Successfully Manufacture Ingot Moulds—Historical Sketch of Concern Which Was the Pioneer in Development of the Direct Metal Ingot Mould.

THE manufacture of ingot moulds is a subject which is of considerable interest to those engaged in steel manufacture. Many steel companies have attempted to manufacture moulds for their own use, some have been successful although many have finally given up the undertaking.

Considerable specialized knowledge and experience is required to successfully manufacture ingot moulds, and due to this fact those who have been successful have been reluctant to give broad publicity to the art. The Valley Mould & Iron Corporation is among the leaders in the manufacture of ingot moulds. This paper relates some of the experiences of that company. This company first began to experiment in the making of ingot moulds from direct metal in 1891 and are, so far as is known, the pioneers of this type of mould.



View of one of the largest ingot moulds ever cast.

In 1892 the original plant at Cleveland, O., was burned out and the company moved to Sharpsville, Pa., on account of the numerous blast furnaces at that point which were available for molten metal, and have been in constant operation since that date in making ingot moulds exclusively.

It was not long before it was discovered that it was not simply a matter of pouring standard Bessemer iron into a flask to produce a good mould. Gradually it developed that certain limitations in the analysis of standard iron was necessary. Other conditions of the molten metal had important influence on the quality and service of the mould so that it was necessary to arrange to have the iron made to special specifications. Special methods of cleaning the hot metal were necessary and the special rigging in which the moulds are made today reached its present form by slow evolution. It took a number of years of close study and experimenting before it was possible to produce a direct metal mould that gave an average service much superior to the old cupola metal mould. To maintain a uniform average service from month to month requires not only close inspection and tests of the condition of the molten metal, analytical checks, reference to data, etc., but also long experience to promptly correct the faults that will develop in the use of direct metal. Today the producing capacity of the four plants of the Valley Mould & Iron Corporation, amounts to 60,000 tons per month, which is sufficient to take care of the normal requirements of the entire United States.

Some claim that cupola moulds are superior to those made from direct metal, experience however seems to indicate the reverse to be true except of course in cases where the design or wall thickness is such as will not admit of proper cleaning of the mould in the manner hereafter described, if made from direct metal. It is only reasonable to expect the direct metal mould to respond more readily than the cupola mould to the expansion and contraction strains that it is required to undergo in service, as it retains most of the original qualities in the iron, whereas the cupola mould loses considerable of its silicon contents and takes up from 20 to 40 points additional sulphur, depending upon the quality of the fuel used to remelt the iron in the cupola. This reaction changes the carbon from the graphitic to the combined state, thus rendering the iron harder and of a closer grain, which naturally makes the mould more susceptible to crack under expansion and contraction strains.

One of the most important steps in the manufacture of ingot moulds is the process of heat treatment which the moulds are required to undergo after they are shaken out of the flasks. This is possible only in a foundry devoted exclusively to the manufacture of moulds on a scale sufficiently large to create at all times a large pile of hot moulds. This hot pile has the effect of annealing the moulds and the larger the hot pile the more thorough the annealing action on the individual moulds.

After leaving the hot pile, the moulds move into the chipping and cleaning building where they are subjected to a rigid inspection before shipment.

The tremendous amount of live equipment which an up-to-date mould foundry is required to carry in stock to properly protect its trade is surprising. The

(Continued on page 128.)

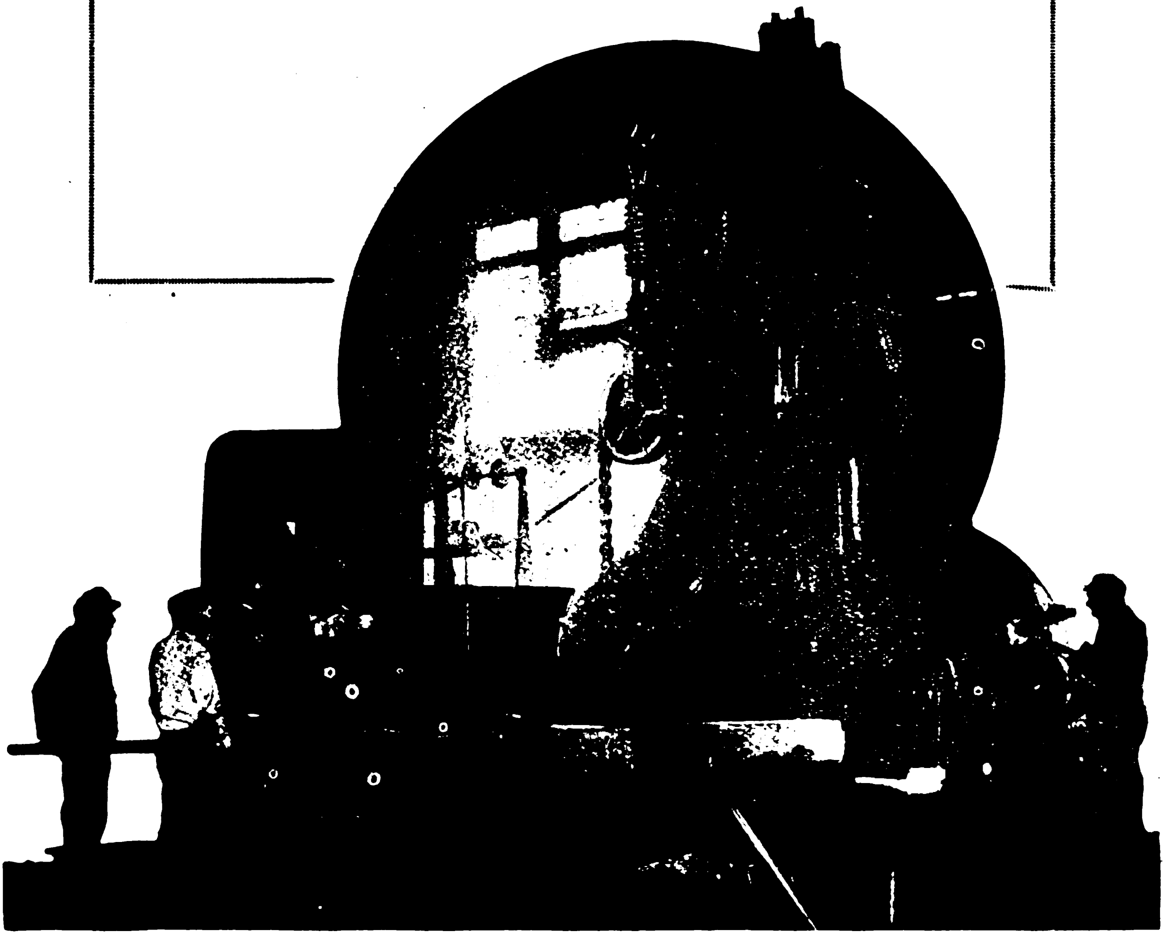
Forging and Heat-Treating Department

THIS department covers the technical developments made during the year in forging and heat-treating. However, some attention is also devoted to heating furnaces.

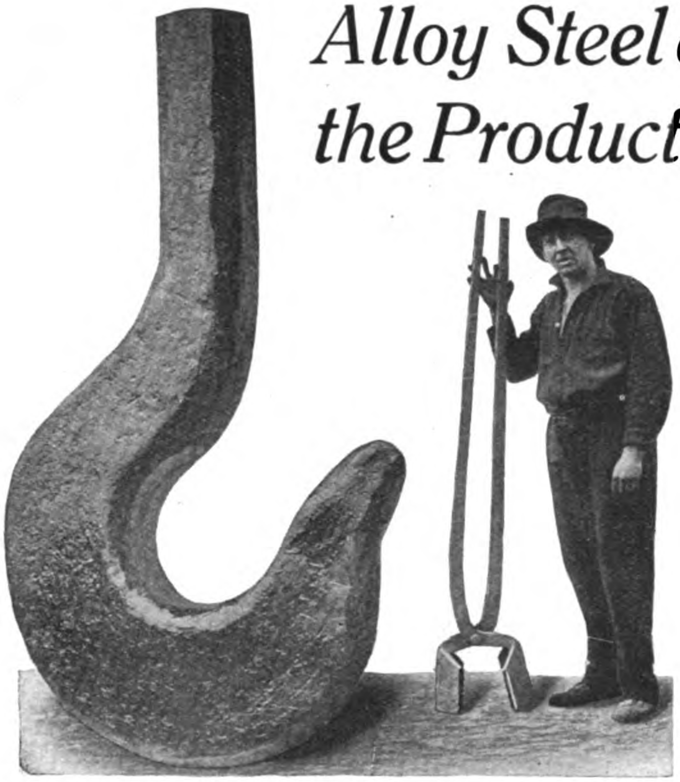
The most important development in forging was the attention given to deep etching of test specimens for the purpose of revealing the presence of slag or other defects before the forging is completed.

Some notable advances have been made in heat-treating furnaces. The "Hump" method of heat-treating is being given serious study and it has been prophesied that this method will be in general use in a few years. Calcium cyanamide is being used in case hardening and it is said that the cost is much less than when sodium cyanide is used.

The question of fuel for furnaces is still being investigated and greater combustion efficiency sought.



Alloy Steel and Heat Treatment in the Production of Special Forgings



Crane hook forged by the American Forge & Machine Co.

American Forge & Machine Co., of Canton, Makes High Grade Chrome-vanadium and Other Alloy Steel Forgings—New Additions and Improvements Being Made in Plant.

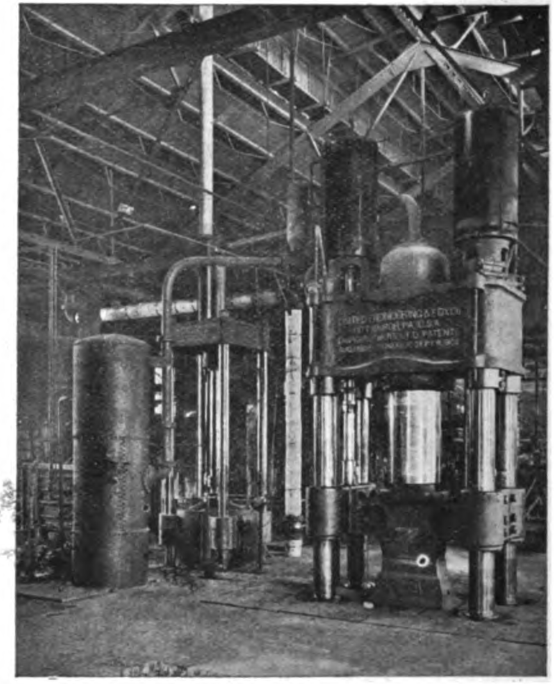
THE principle of making especially tough forgings by "working" out the metal with pressure, instead of hammering it out by impact, has been understood for hundreds of years. The sword blades and gun barrels of Damascus and Toledo were forged by this process, but it is only within the past few years that American manufacturers have worked out the details of applying it to heavy forgings.

The company whose plant is briefly described and illustrated in this article, was one of the first drop forging concerns in this country to add large steam hydraulic forging process in addition to its batteries of steam hammers. The firm is chiefly engaged in manufacturing special high grade chrome-vanadium and alloy steel forgings of moderate size.

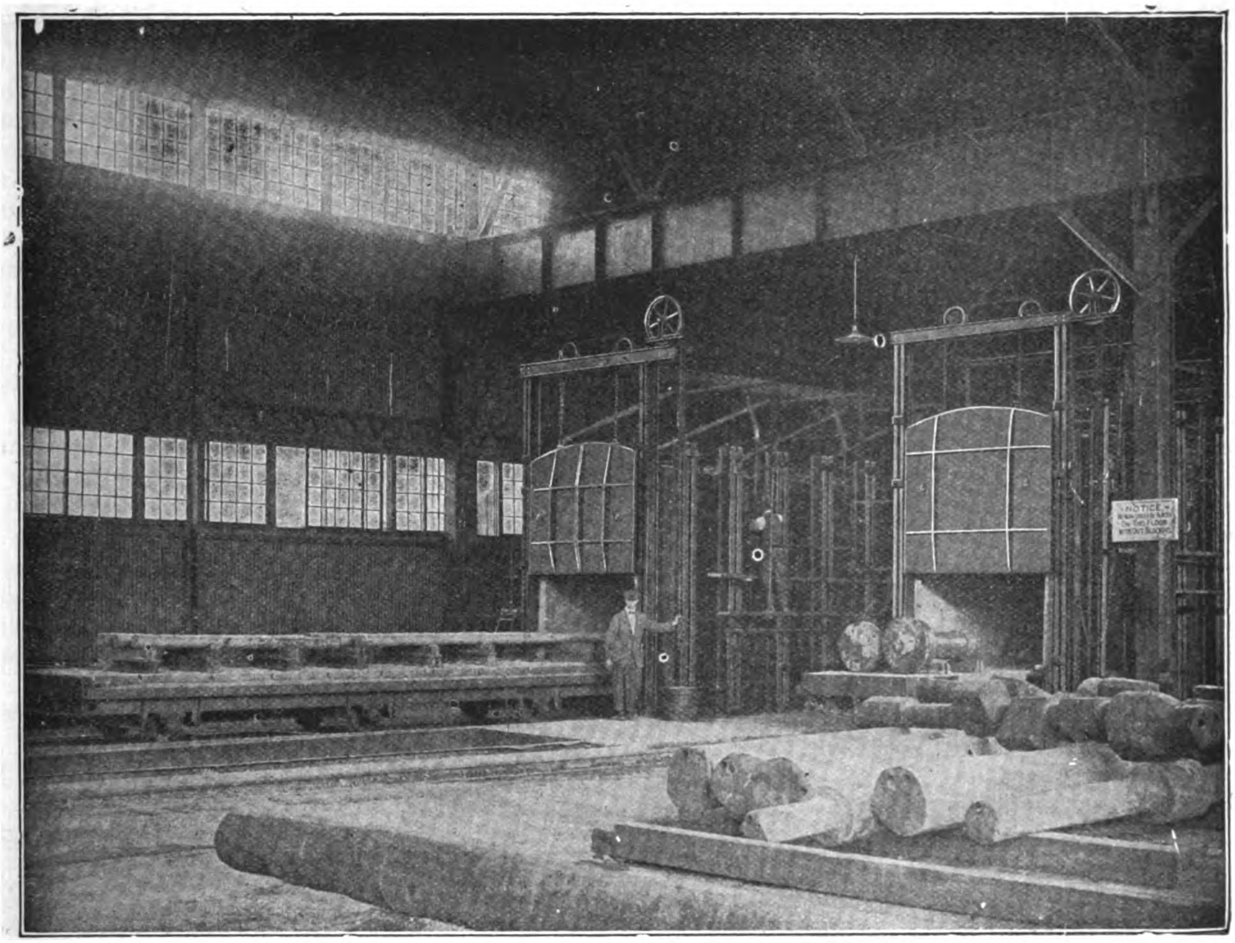
The entire organization of the American Forge & Machine Co. consists of men who have specialized for years in meeting the most exacting requirements of manufacturers in the way of drop and drawn forgings. Every department is directed by men who have become specialists in that particular work.

Outside the great ordnance works in the United States and England, the American Forge and Machine Company, of Canton, was one of the first drop forging plants in this country to add large steam hydraulic forging presses to its equipment, in addition to its batteries of steam hammers. Being among the first to embark upon this development, and being in an unusually favorable position to obtain high grade chrome-vanadium and other alloy steels, the growth of this company's business has been very largely along the line of special alloy steel forgings, of moderate size (2 tons to 15 tons in weight) for special purposes.

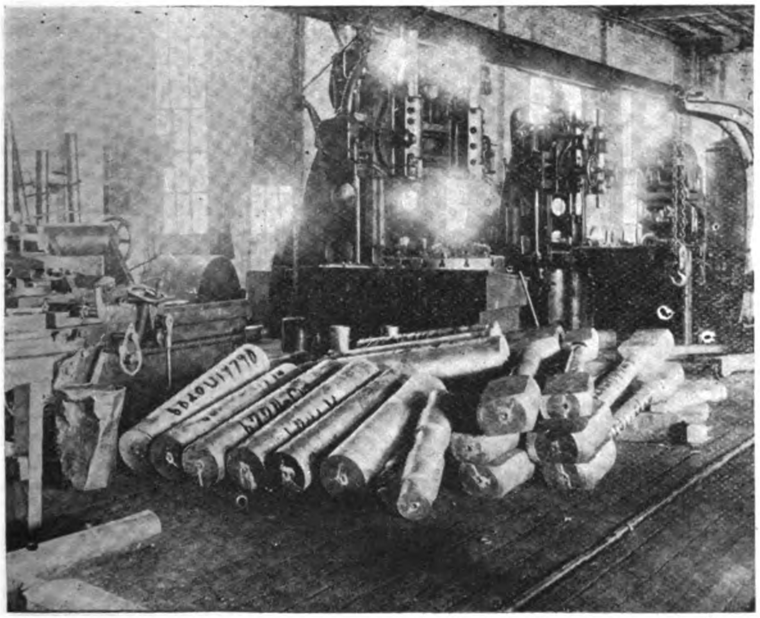
Owing again to its favorable position with reference to alloy steel, the American Forge & Machine Co. was able quickly to develop a system of heating, handling and manipulation preliminary to the forging process that produced an exceptionally tough and dependable forging. In the forging process itself the company simultaneously developed improved methods of handling the ingot or bloom at the forging press, and subsequently, recognizing it as an additional factor making for toughness and strength in the finished work, it added a heat treating department to the plant. This department is now showing remarkable results, as it was designed and is operated with special reference to accuracy in every stage of the process.



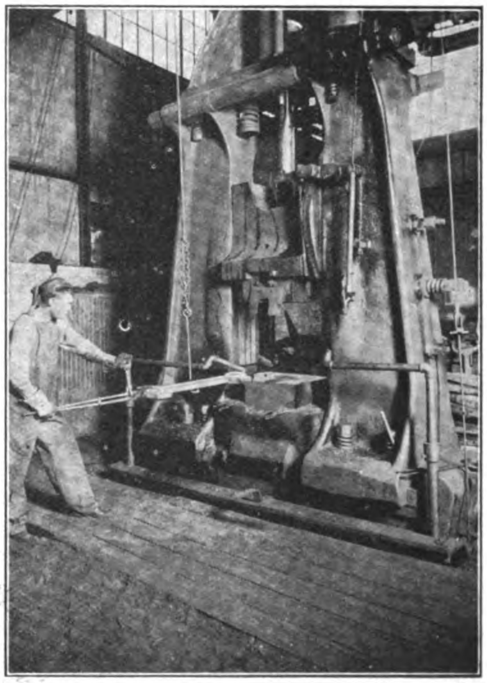
600 Ton steam hydraulic forging press.



Heat-treating department.



View of machine shop where forgings are machined.

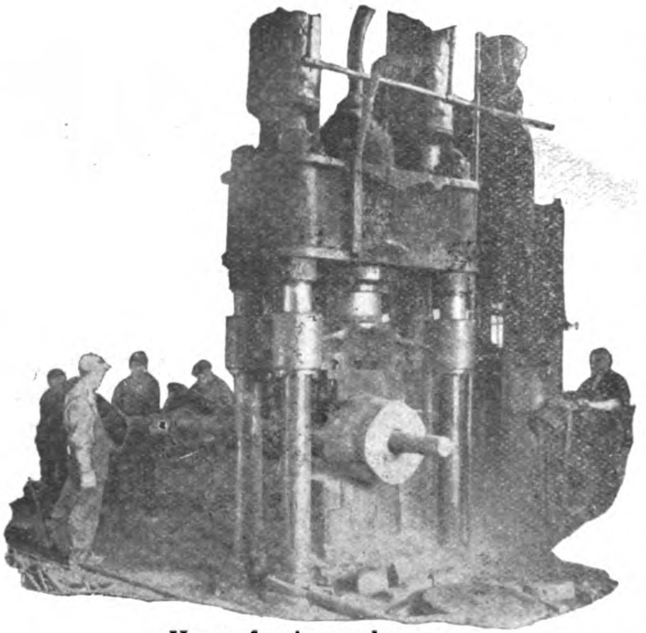


Hammer for small forgings.

This plant, which is housed in a separate building, is equipped with electric cranes, and with heating furnaces of all sizes necessary to handle large and small forgings. Large furnaces are of the car type and are equipped with delicate recording pyrometers that reduce the possibility of error, not only with respect to temperature, but also with respect to time of treatment, to a minimum.

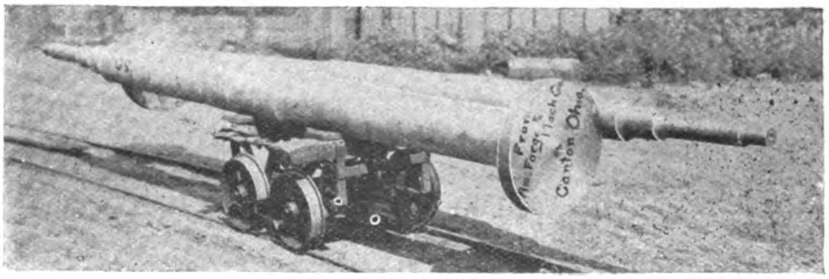
This department is also equipped with suitable quenching tanks and conveyors, the final result being forgings that, during the war period, were able to measure up at all times to the most rigid specifications of the government.

In a separate department the company has developed a complete equipment of motor driven lathes, planers, boring mills, saws, slotters, drill presses, etc., on which it is able to rough machine the heaviest forgings produced in its shop. The company prefers to send out all its heavy work in the rough machined conditions as this practically eliminates the chance that costly errors will be made by the machinists who are to do the finishing work.


Heavy forging under press

In the heavy forging department the company is able to handle any kind of special alloy steel ingots or blooms up to 15 tons in weight, 30 feet in length and 16 inches in diameter. Within these limits the metal is heated in special furnaces, (equipped to burn gas or oil or a combination of both) the process having special reference first to the composition of the steel, and second to the size of the unforged metal. It is then "worked" or "pressed" (not hammered) under a 600-ton United Engineering & Foundry Co. hydraulic forging press of the steam intensifier type, roughly to size and shape. With this equipment, and with its highly specialized experience, this plant can produce all kinds of heavy mill and other forgings that are required to withstand the most tremendous shocks and strains.

Locomotive driving axles, steam hammer piston rods, hot mill screws and boxes, die blocks, crane hooks, porter chain links and pins, rolling mill drive shafts, large gear blanks, turning and galvanizing rolls, and gun forgings, are among the products from which the company has gained its reputation for forgings. For example, the American Forge & Machine Co. early developed a certain alloy steel link and pin for heavy porter or hoisting chains, which, being specially worked and accurately heat treated, has practically replaced all other chains on most of the large presses in this country. The testimony of users is that these chains give excellent service under trying conditions. The same is true of a special chrome vanadium steel hot mill screw and box made by the company for many of the leading rolling mills in the country. Forgings are also made in this plant for submarine chasers, aeroplane motors, gun carriages and trench mortars, all of the latter being remarkable for the fact that they successfully meet the rigid specifications of the government with practically no rejections. Another class of forgings produced by the hydraulic forging press department is used by locomotive and electric car builders, for heavy duty driving axles.


Showing machined forging

This plant is unlike most other forge shops in that it is able to produce both drop and drawn forgings. In the drop forging department the equipment consists of steam drop hammers ranging from 1,000 to 6,000 pounds, with suitable furnace and auxiliary equipment, designed especially to give dependable and reliable service. Wherever experience has shown it to be necessary, duplicate equipment is provided to prevent shutdowns and other delays that would cause loss or inconvenience to customers.

A large addition to the drop forging plant is now under way. It will be housed in a modern steel building 65x300 feet. In the new plant, all piping for hammers will be run in concrete tunnels and every possible provision will be made to forestall the necessity of shutting down any part of the plant for any cause. This addition to the drop forging department will have an entire new battery of hammers from 2,000 to 8,000 pound capacity, special trimming presses and the latest type of furnaces.

As a part of this development the company is also erecting a new power plant, which is to be the last word in modern design. All boilers will have underfeed stokers, and suitable conveying machinery for fuel and ashes. The engine room will be equipped with low pressure turbines, generating current to be used throughout the plant.

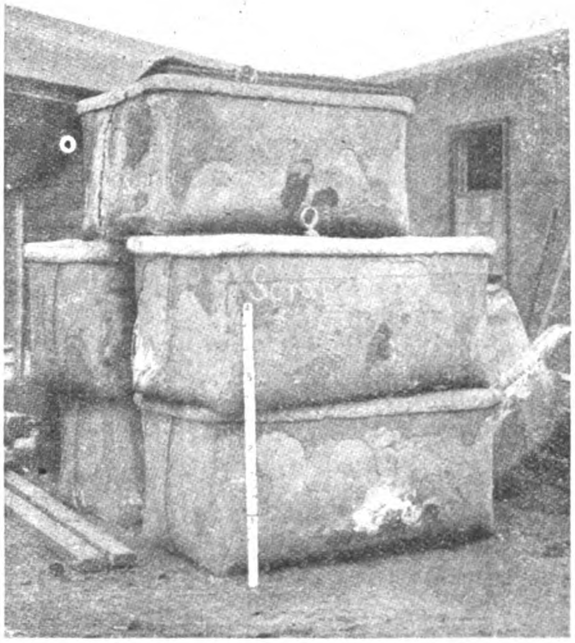
Calorizing Process to Prevent Oxidation

Calorizing Process, Which Consists of Applying a Mixture of Alumina and Other Ingredients at High Temperature to Metallic Surface Protects Treated Parts From High Temperature Oxidation

By G. F. BURGER.

NEW developments are constantly adding to the scope and application of metals for industrial purposes. Oxidation has, since the beginning of the use of ferrous-metals, been an outstanding trouble experienced by metal users. The earliest oxidation trouble was that experienced from atmospheric or moist conditions, and millions of dollars worth of metal have been destroyed and have built up mammoth scrap heaps of rusted iron and steel equipment.

As the handling of iron and steel, especially during the last two decades, has become more understood, another form of oxidation has taken its place alongside of the problem of rust. Iron and steel users began to heat-treat metals, and as the process of heat treatment proceeded, the problem of oxidation increased. Today scarcely an industrial organization using metal is without its heat-treating department, the great resulting wastage of money and material from oxidation under high temperatures is tremendously apparent. The loss of production caused by laying up productive equipment for repairs to, or replacement of, oxidized parts, is incalculable. Heat-treaters, furnace builders, engine builders, stove manufacturers, steel manufacturers, chemists, and metallurgists, have sought long and earnestly for a solution of their oxidizing problems.



Calorized annealing boxes.

As iron and steel are the metals most common in use and most subject to oxidation from heat, investigation very naturally applied particularly to these base metals. It had been known long before any process was devised that the black oxide on iron was a fair protection and the effort proceeded along the lines of maintaining this protection, with but little success.

A number of processes have been developed to prevent oxidation of metallic parts. The Bower-Barff process was among the first developed and in this process the metal was heated to 900 degrees C. in a closed retort, then subjected to superheated steam for a short interval. When a coating of red and black oxides had formed, the metal was exposed to producer gas and allowed to cool to a lower temperature, when the parts were oiled. A green black coating thus produced afforded protection from sea-water, acid fumes, and considerable variation in temperatures.

The Gesmer process was a further development of the Bower-Barff process. After treatment by steam at 900 degrees C. a small quantity of naphtha or hydrocarbon oil was introduced to reduce the red oxide and to carbonize the surface. The resulting coating analyzed as a compound of iron, hydrogen and carbon with a minimum of 2 per cent hydrogen. This process reduced the warpage and the tendency to scale.

The process known as Coslettizing was an effort to develop a process by chemical means. The parts were cleaned by pickling or sand blasting, and then placed in a boiling solution of dilute phospheric acid with iron or zinc filings. After a varying period of treatment the parts were dried and oiled. This process converted the surface into certain phosphates of iron but the major part of the coating resulted from the solution. Metal coatings were tried, notably zinc, and certain alloys which were strongly electropositive to iron, with partial success.

Hot galvanizing and cold galvanizing were developed and are generally known processes, but the first limited the corrosive substances in the coating and the latter was liable to be porous and contain acids which were detrimental. These processes consisted of coatings and are subject to the objection of possible removal.

The Lohman process consisted of a dipping operation in acids and molten metal and afforded a better junction between the iron and the protective alloy than the processes before mentioned. This treatment was further developed in the Sherardizing process. The parts were placed in a retort with finely powdered zinc and zinc oxide and heated in a reducing atmosphere for a length of time relative to the coating desired. The coating consisted of four layers; an alloy with a large proportion of the base metal, another defined layer of alloy containing more zinc; a layer of more or less unknown alloys and finally a layer of pure zinc. This coating resists

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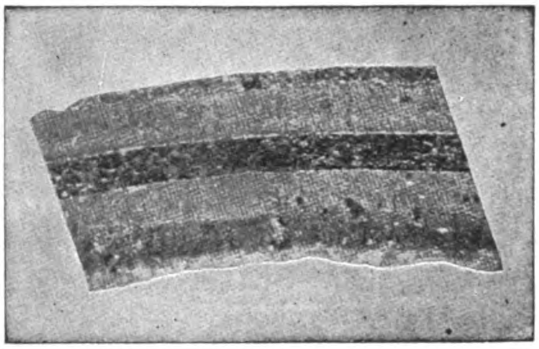
atmospheric oxidation or rust very successfully, but as the zinc is volatile, has little effectiveness against oxidation in high temperatures.

The Schoop process is more recent and incorporates the application of molten alloys by means of compressed air at high velocity directly on the parts treated. A continuous coating which is exceedingly intimate is developed but as in most of the processes described, the treatment is expensive, and further, holds objections in the necessarily mechanical handling.

Among the concerns which experienced considerable difficulty as a result of oxidation, under high temperatures, was the General Electric Company. Electrical heating units manufactured by this company suffered much from constant oxidation. Finally its research laboratories were instructed to thoroughly investigate this problem. After extensive experimenting and research the process of calorizing was evolved, and in time developed for their use with most gratifying results.

Other concerns having heard of this new calorizing process for the prevention of oxidation of metals at high temperatures, began to interest themselves in the process and it was subsequently tried out in a very large way by the Diamond Power Specialty Company, a well known boiler equipment concern in the Middle West. Here, also, it gave a much increased life to the parts exposed to high temperature combustion and proved a decided success. As a result of the highly satisfactory and valuable results obtained with the new process, it was decided to form a company to place the process on the market in a commercial way and the Calorizing Corporation of America was formed, to operate as prime licensees under the General Electric Company patents, and to carry on a commercial business of calorizing and to issue sub-licenses to large industries whose requirements were large enough to warrant their own calorizing equipment in their plants.



Section of calorized material.

Calorizing is accomplished by packing the parts to be calorized, together with a mixture of alumina, in tubular retorts which are revolved in suitable furnaces, under a temperature of approximately 1,700 degrees F. The mixture is composed of a percentage of pure alumina, oxides and other ingredients. Hydrogen gas is constantly introduced into the retort while operating. The parts to be treated are first thoroughly sand blasted to expose a clean metallic surface for treatment. After slowly bringing the furnace up to about 1,700 degrees F., the heat is maintained at this point for aproximately three hours, and the retort is then allowed to cool slowly, with the injection of the hydrogen gas still continuing. When cold, the flange header is removed and the parts are taken from the retort and cleaned. The aluminum content of the dry powdery mixture has been reduced in proportion to the percentage which has impregnated the surface of the treated metal. This penetration is actual and the depth depends upon the amount of pure aluminum in the mixture, the degree of heat and the length of time the process is operated. For ordinary commercial requirements a penetration of 0.02 in. has been found satisfactory.

The aluminum of the metal forms a homogeneous alloy with the surface, and so long as this surface is not broken up by drilling, machining or abrasion, it will resist oxidation at temperatures ranging up to 1,800 degrees F.

The calorized surface is comparatively smooth and may be buffed to a high finish. The diameter of treated parts is but very slightly increased, since the treatment is an impregnation rather than a coating, but the calorizing makes the surface of the treated pieces considerably harder. During the calorizing process the threaded ends of rods and tubes are protected by the application of silicate of soda, which can later be removed by means of taps or dies.

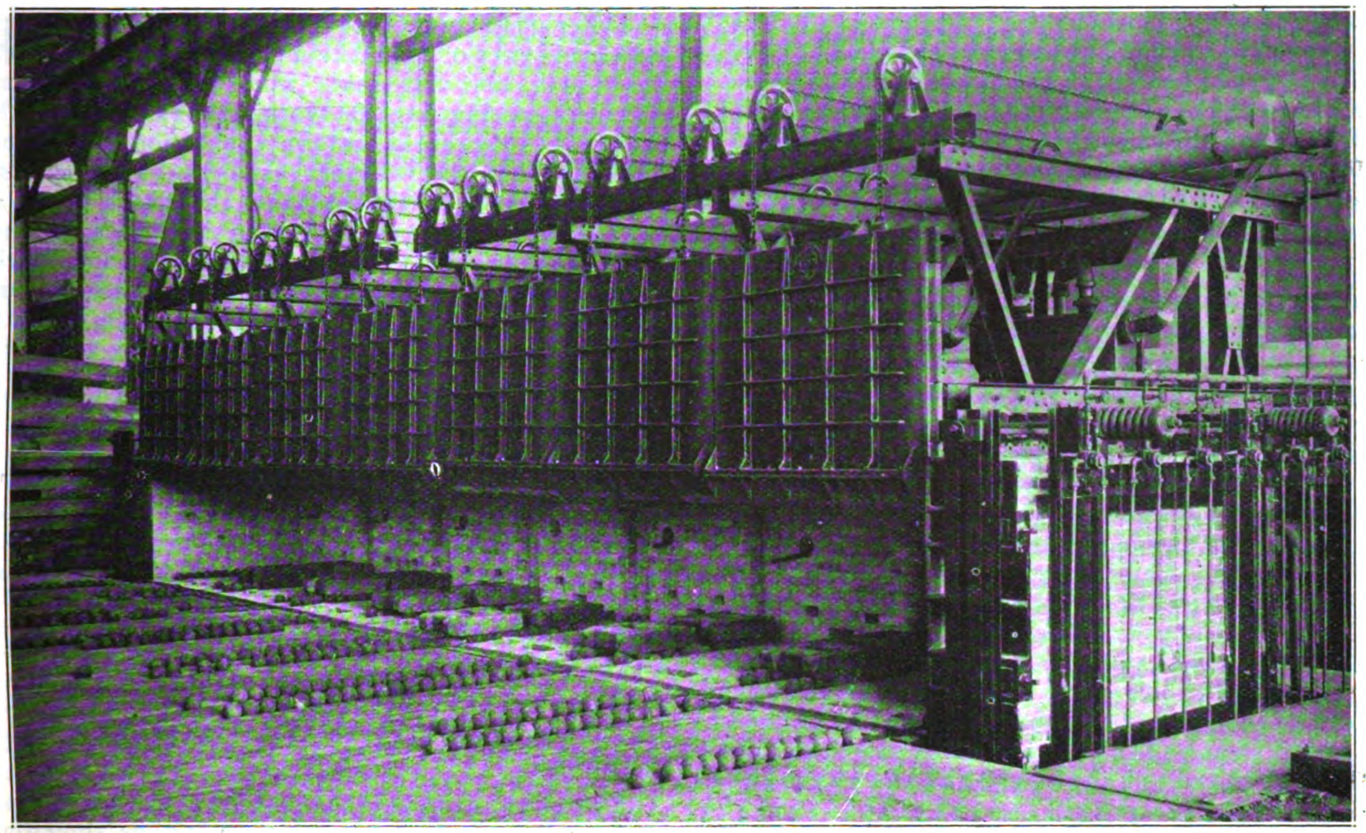
Good grades of cast iron, wrought iron, malleable iron, steel, nickel, nickel-steel, copper, brass, bronze, etc., can readily be calorized with excellent results.

The application of calorizing to metal parts affords an exceptional range of use. Wherever heat is used, and results in oxidation of metals at combustion temperatures ranging up to 1,800 degrees F., it is claimed calorizing will appreciably increase the life of the untreated metal parts. Owing to the wide variation of heat conditions in industrial plants throughout the country, it has been found impossible to guarantee specific results. It has been found that in certain cases treated metals have lasted 30 times as long as those which were not treated.

The calorizing of carbonizing pots, roasting pans, annealing boxes, furnace parts, burners, valves, pyrometer protection tubes, retorts, heating, refining and various other equipment incorporates, it is stated, a large saving to users. Many and varied tests have shown the decided superiority of calorized metal in resisting oxidation from high temperatures.

Calorized metals, especially brass and copper, show decided resistance to the action of certain acids and gases. It will not however, prevent atmospheric oxidation (or rust), from moisture.

Where requirements of plants are sufficiently large it has been arranged to sub-license the process and as the expense of furnace construction and equipment is not large, this feature opens up possibilities to large industries.



New type of heat treating furnace developed during the year.

Technical Advances in Forging During 1919

Two Important Developments of the Past Year in Forging Practice: Deep Etching of Test Specimens to Detect Flaws, and New Type of Heat Treating Furnace.

By **HENRY FREEMAN.**

THE year 1919 has benefited by the intense study and concentration on the many difficult problems and conditions which developed in the forging line during the recent trying war period. The solution of some of these problems came to light during this year and are being detailed in the various trade journals. There are two developments, however, deserving of special mention because of their importance to the forging world.

The most important to my mind is deep etching of test specimens to reveal the presence of slag inclusions or other defects (should there be any) before the forging has been completed. This practice has been in use by some firms making forgings for United States army ordnance requirements who cogged down the original ingot about 50 per cent, but before sending it to a smaller press for final forging, slugs were taken out and immersed in a solution of hydrochloric acid for a given period; if there were any inclusions they would show up very clearly, the clean steel was passed on to be finish forged and that showing inclusions was rejected.

The subject of deep etching was discussed from a different angle in a paper presented by F. M. Waring and K. E. Hoffman at the annual meeting of the American Society for Testing Materials, Atlantic City, June 24 and 27, 1919.

We find that the physical test and a photomicrograph of a test piece polished and etched will reflect the condition of the steel, a microphotograph of the same specimen not etched will show if there are inclusions; but you cannot convince your steel man with a picture that his steel is bad. Now take this same specimen and immerse it in hydrochloric acid for 30 minutes, the inclusions will be eroded and a lot of cavities will remain.

In other words the structure of the steel after heat treatment as shown by a photomicrograph of a test specimen polished and etched, may be perfect; yet will fall short in elongation in the pull test, and be rejected.

A photomicrograph of this bar unetched will show the inclusions and the cause of the failure. Deep etching as described above will show up inclusions in all their nakedness and you do not need a jury of experts to diagnose the trouble.

Figures No. 1, 2, and 3 show three standard test bars taken with hollow drill not machined, all have been immersed in acid bath same length of time, they are all 3¼ per cent acid nickel steel of the same approximate chemical analysis.

The other subject worthy of special mention marks a radical departure in furnace construction. It was designed by R. C. Drinker and built by the Rockwell Company. It is a new type of heat treating furnace and opens at the side and is described as follows:

Owing to the wide range of work handled by many forge shops, it has been difficult until recently to get a type of furnace in which all this material (differing widely in shape and size) could be satisfactorily heat treated. Furnaces of the car type, or of the lift-off or bung type, have been commonly used, but both of these types have a great many disadvantages.

To overcome these disadvantages Mr. Drinker has developed a side opening type of furnace as illustrated on page 111. This furnace has a chamber 5 feet 9 inches wide, 36 feet long, which is the full length of the furnace. (The owners of the furnace shown are so well pleased with it that it will be lengthened to 105 feet in the chamber, to anneal and heat-treat the largest shafts and similar pieces handled by a forge shop.) The construction is such that the furnace can be built of any length and any reasonable depth.

This furnace is provided with movable partition walls and can be divided into seven separate chambers, each approximately 5 feet 0 inches wide. The doors covering the working openings can be raised or lowered independently of one another, or may be raised or lowered in quick succession. The doors are dove-tailed and form guides within themselves that prevent the escape of hot gases, the only gases which escape being exhaust gases that leave through the regular vents.

The doors are raised and lowered by counterweights and compressed air. The counterweights weigh almost as much as the doors, so the compressed air used is very slight indeed. At the end of the furnace are located the individual valves for operating the air hoists, from which point the operator can see the doors.

The roof of this furnace is constructed of flat tiles, eliminating the thrust caused by the ordinary arch construction. The roof, as well as the door lift rigs, are suspended by the overhead truss as shown in the illustration.

Oil or gas may be used as fuel. Combustion takes place in a series of combustion chambers located under the hearth, the hot gases from these combustion chambers passing into the working chambers in such manner as to insure a uniform application of heat to the material in the working chambers. The location of the combustion chambers under the hearth insure a hot bottom and the best of heating conditions. Some of the gases in the heating chamber are siphoned back into the combustion chambers so as to create a circulation, which prevents any dead spaces in the heating chamber.

Even the heat in the waste gases is utilized. These waste gases as they leave the vents circulate around the preheaters at the rear of the furnace arranged above the vents. The air in these preheaters thus takes up the waste heat and brings back through the burners the greater part of the waste heat that would otherwise escape. The fuel consumption in this furnace is extremely low due to the efficient application of the heat and the utilization of the waste heat ordinarily lost.

Provision is made for the convenient control of the burners from above the floor line at the back of the furnace.

Expansion of the bridge work, or of the furnace as a whole, is taken up by the take-up springs shown at the side of the furnace. The overhead truss has been divided so as to prevent any distortion due to the heat in the furnace.

If the pieces to be heated are small, they can be placed on the floor of the furnace, or if they are large and rather unwieldly, heavy cast steel trucks are provided, upon which the pieces are supported, special provision even being made to take care of the expansion of the pieces within the furnace.

Among other developments of interest during the year might be mentioned a heating and cooling curve for large ingots of forgings, this work has been carried on largely by F. E. Bash of the Leeds & Northrup Co. at the plants of the Allis-Chalmers Manufacturing Company, and the Sizer Forge Company, and proves the absolute necessity of preheating a large ingot for a long period at low temperature, approximately 700 to 1,000 degrees F., before placing in the heating furnace. The curve will show at what rate the heat should be applied so as to get a minimum differ-

(Continued on page 128.)

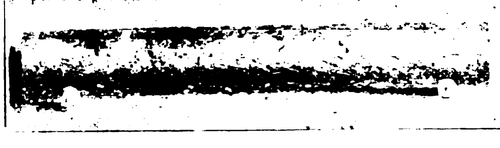


Fig. 1.

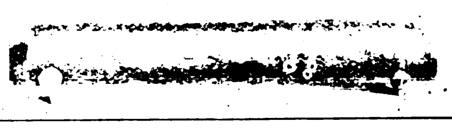


Fig. 2.

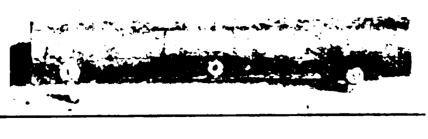


Fig. 3.

Analysis:	No. 1—An example of dirty steel	No. 2—Not so dirty	No. 3—Clean steel
Tensile strength	84,200	89.700	83,800
Elastic limit	55,350	54,850	63,500
Elongation	7%	13.5%	28%
Reduction of area	14%	17%	65%
Character of fracture	Angular Spotted	Angular Spotted	Silky Cup

Heat Treating Methods Improved in 1919

Recounts New and Improved Methods—Effect of Time in Tempering—Use of Calcium Cyanamide and Other Improvements in Case Hardening—"Hump" Method in Heat Treating.

By B. F. WESTON,

IT has been well said that, "the science of heat treating steel has become well established, but, the art of heat treating has its many problems ever before us," and, in a general way, this quotation may be accepted, for, as has been said, the scientific and technical reasons for the various operations of heat treating change but slightly in a short time, generally speaking, and the science is built up, like many other sciences, little by little each new development, small as it may be, helping to push forward the science as a whole. It is in the art, by the various applications of new and improved furnaces, pyrometers, quenching mediums, carbonizing materials, etc., that the more recent and striking advances have been made.

It is hard for me to pass to the subject matter of this article without calling attention to the more recent methods of testing steel products, namely, the examination of finished material by means of the X-Ray and also by magnetic testing. It is rather unusual to pick up a journal in any way connected with the manufacture and metallurgy of steel, not to find one or more articles on these methods of testing. The experienced metallurgist knows full well that the ordinary methods of testing do not always tell the whole story, that it is very possible for a faulty bar, or part, having hidden imperfections, to pass inspection by the usual methods, no matter how carefully and faithfully done.

With the foregoing words, the writer will review what he believes to be among the more recent advances in heat treating.

Effect of Time in Tempering.

The effect of time on the operation of tempering, or drawing back, hardened steel is very noticeable, and, has been more recently brought out in connection with work on rifle barrel steel of the following composition: Carbon, .54; sulphur, .05; manganese, 1.22; phosphorus, .065. As can be readily seen, heat treated steel for this purpose must drill with as little difficulty as possible, and, yet have high physical properties, which, on two lots, are as follows: Lot No. 1 gave serious trouble in drilling. Lot No. 2 gave no trouble. The physical properties on these two lots are as follows:

	Lot No. 1	Lot No. 2
Elastic limit, pounds per square inch....	117,450	116,800
Tensile strength, pounds per square inch	132,500	131,750
Elongation, per cent	16.0	20.0
Reduction of area	42.1	51.0
Impact strength ft. lbs. per square inch..	450	520

The machinability and physical properties were due entirely to the time of tempering, or reheating.

Both lots were oil quenched from 1,500 degrees F and reheated, or, tempered, at 1,180 degrees F. Lot No. 1 was reheated for 30 minutes. Lot No. 2 was held at temperature two hours. In both cases, 20 to 30 minutes was required to bring the work up to the above temperature of 1,180 degrees F., which was not taken into the above account.

Further tests on different lots of steel show the increase in machinability, ductility, and resilience obtainable by increasing the time of drawback, which was one hour, two hours, three hours, four hours, and 12 hours. There was a slight decrease in elastic limit and tensile strength as the tempering, or drawback time was increased, which, however, is slight, compared to the relatively great increase in ductility and impact strength. The decrease in elastic limit of less than 1 per cent is accompanied by an increase of 25 per cent in ductility, as measured by elongation and 13 per cent increase in impact strength. The foregoing tests were obtained on standard test specimen taken from heat treated bars 1 1/32 inches in diameter.

Improvement in Case Hardening.

As flaking and chipping of the case in case hardening steel, especially of nickel steel containing higher percentage of nickel, causes the heat treater more or less trouble, it is worthy of note that this undesirable quality has recently been the subject of research to determine, if possible, the cause and cure.

Chiefly, the causes seem to be, the excessive concentration of free cementite in the case and the sharp line of contact between the coarse network of the cementite, composing the case, and the ferrite of the core. Of lesser importance is the local effect of grinding.

Having diagnosed the case, it is up to the metallurgist to apply his theories to practise. Without, however, going into the theory of case hardening, it may only be necessary to say that a method of carburizing in such a manner as to produce very little of the coarse network of cementite, or to break up any formed, is a desideratum, and, in the following method of carburizing, theory and practice seem to work together.

Pieces of nickel steel were carburized at 900 degrees C. (1,652 degrees F.) for a given time, and, as has been shown, the outer case contained a high concentration of carbide. The temperature was then reduced to 800 degrees C. (1,472 degrees F.) for a given time, this temperature being the refining temperature of the core. The specimens were cooled in the box.

The microscope showed the outer portion of the case to contain only a slight cementite network, and, when subjecting the specimens to quenching from 800 degrees C. (1,652 degrees F.), no cementite was

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left undissolved and the structure consisted of a uniformly fine martensite.

The foregoing treatment may be modified by a gradual lowering from the carburizing temperature of 900 degrees C. (1,652 degrees F.) down to 800 degrees C. (1,472 degrees F.) with cooling in the box and subsequent quenching as usual.

The main points appear to be the quenching of the steel from a temperature, at which the excess of carbide is dissolved, and, also of a change in already existing treatment during the carburizing, whereby a case of nearly eutectoid composition is obtained.

The above method, given only in abbreviated form, has been adopted and in practical use for some months with nearly a complete elimination of scrap losses.

"Hump" Method of Heat Treatment.

At one of the sessions of the American Steel Treaters' Convention, held in Chicago in September, a paper was read describing the "Hump" method of treatment, which appears very practical.

The heating is done in an electric furnace, thus insuring a uniform heat and absolutely under temperature control. The thermocouple of iron-constantan, composed of No. 8 bare wire, projecting up through the center of the bottom of the round furnace with the hot junction in the middle of the hot furnace, the bottom of the furnace being sealed so that the atmosphere is kept as nearly neutral as possible. The couple is connected to a curve drawing recorder showing the temperature of the hot junction. With the furnace at 1,400 degrees F. and current cut off, the tool is suspended by a small wire into the furnace, so that it touches, or is close to the junction of the couple.

The furnace is then covered. The temperature of the furnace and couple will drop several hundred degrees, and, as the tool absorbs the heat of the furnace, its temperature rises, as does the temperature of the couple. The switch is closed, and, by means of the rheostat, the curve is so regulated that the temperature of the furnace walls, the couple, and all parts of the work are increased at, approximately, the same rate. When the transformation point of the tool has been reached, there is a lag in the temperature of the steel, due to heat absorption, and, this lag effects the couple, so that a marked change in the slope of the time-temperature curve occurs as is shown by the recorder. When this transformation is complete, there is another abrupt change in the time-temperature curve. It is only necessary to heat the tool above the second change in the curve a certain distance, according to size, mass of steel, and the quenching medium. This distance depends largely on the skill and experience of the hardener. The first change in the curve indicates the beginning of the transformation point, the second change the ending of the transformation. By heating the tool for hardening by this method, the steel is given the best known treatment to produce the correct grain size in the sample, thus giving it its best physical properties when hardened, and, it is plain that as long as the same shape of the curve is observed for the same type of tool, and, though the pyrometer may be reading inaccurately, that the structure of the hardened steel will be the same in all cases, and, to repeat, the correct theoretical point can be determined for quenching each lot of steel of varying analyses, regardless of inaccurate pyrometers.

It has been prophesied that this method will be in general use in a few years, and, it appears that it might be used to determine the correct hardening temperature with any furnace, whose temperature may be absolutely controlled, such as the electric or the gas furnace whose heat control is subject to the action of one valve.

Calcium Cyanamide in Case Hardening.

The science of case hardening has made very little advancement in the past, even from its inception, while the art has, of course, progressed, and, today various carbonaceous materials are used under close pyrometric control, as are also various gases under high temperature and pressure, to convey carbon to the material being treated.

Case hardening of steel is also brought about by immersing the article to be cased in melted potassium or sodium cyanide for varying lengths of time according to the depth of case desired. The cyanides are very poisonous salts, as well as expensive, and, recently a new process has been brought out involving the use of calcium cyanamide, a product of the electric furnace, and, which is used, primarily as a fertilizer, conveying nitrogen to the soil. When used as a case hardening material, it is placed in an iron basket and immersed in a melted bath, consisting of a mixture of sodium chloride, calcium chloride, and barium chloride, or, a mixture of sodium chloride and potassuim chloride in an iron pot. These materials in themselves do not possess the property of adding carbon (casing) to the red hot steel. A vigorous evolution of gas takes place upon the addition of the calcium cyanamide and the bath then acquires case hardening properties lasting while the evolution of gas continues. During this period, the article to be cased is immersed, and, if the evolution of the gas is too vigorous, the iron basket may be removed from the bath, while the case hardening continues for some time after this removal.

Arrangements have been made with the manufacturers of calcium cyanamide to select a high grade product for this process, which is to be carefully packed in airtight cans for shipment.

The cost of using calcium cyanamide is said to be much less, being about one-fifth as much as when using sodium cyanide, with equally satisfactory results, and, with more comfortable and healthful conditions to the workmen. I am reliably informed that, pending the completion of arrangements to put the process on a business footing, the inventor is engaged in perfecting the adaptation of it to every variety of work and hopes to be in position to introduce it regularly very soon.

Electric Furnace Installation for Heat Treatment of Ball Bearing Races

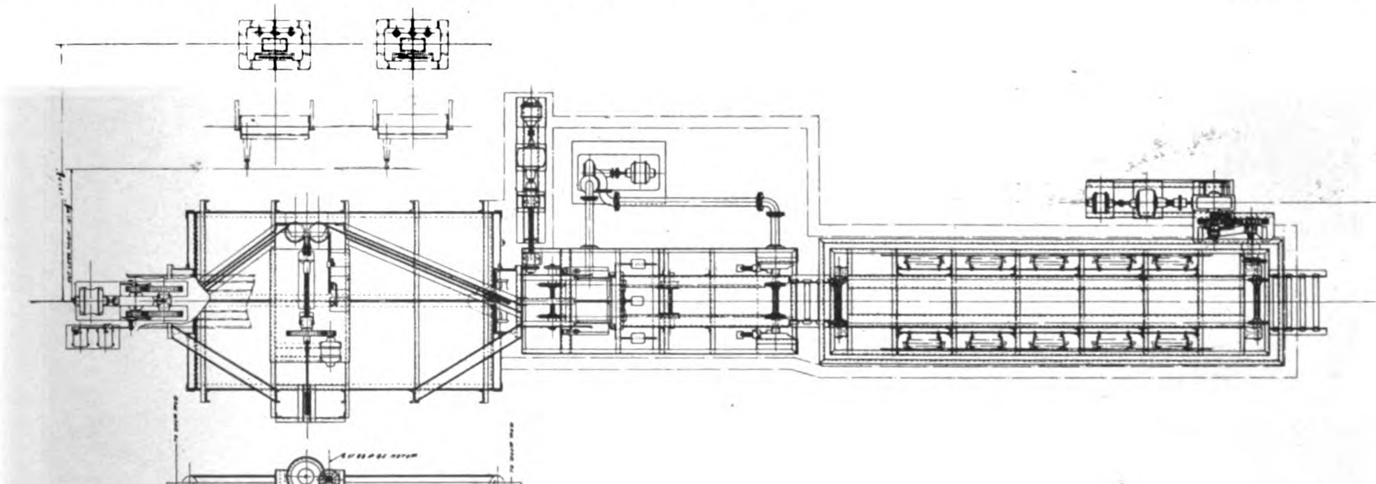
Treating Equipment Consisting of a Pusher Type Furnace, an Oil Quench Tank and an Oil Drawing Bath Arranged in Series for Continuous Flow of Material.

THE STANDARD ROLLER BEARING plant of the Standard Steel & Bearings Co., Inc., Philadelphia, Pa., has recently placed in operation an automatic electric heat treating set for treating ball and roller bearing races.

This equipment comprises essentially, a through type pusher furnace, an oil quench tank and an oil drawing bath, arranged in series for a continuous flow of material as shown by the accompanying general arrangement drawing. Both the furnace and oil draw tank are electrically heated and the flow of material through the treating set is controlled by a clock contactor.

The intervals between contacts may be varied over a considerable range to accommodate different classes of material. The hardening furnace is of the standard carbon resistor type built by the furnace company and is rated at 150 kw. The furnace is equipped with a pyrometer and for average tool steel is maintained at 1,525 degrees F. The drawing tank has nichrome resistors immersed in the oil and arranged along the sides of the tank, the oil being maintained at a temperature of about 350 degrees F. by means of an automatic temperature controller. About 40 kw is required for the draw tank when in operation, handling 1,000 to 1,200 pounds of material per hour.

The rings are placed in perforated metal trays holding approximately 125 pounds. These trays are then placed in front of the pusher which is motor operated. At intervals corresponding to the setting of the clock contactor, the doors open and the tray is pushed into the furnace, at the same time a tray which has reached the correct hardening temperature is pushed out of the far end of the furnace and slides down the incline into the oil quench where it is immersed.



Plan and elevation of electric heat treating furnace.

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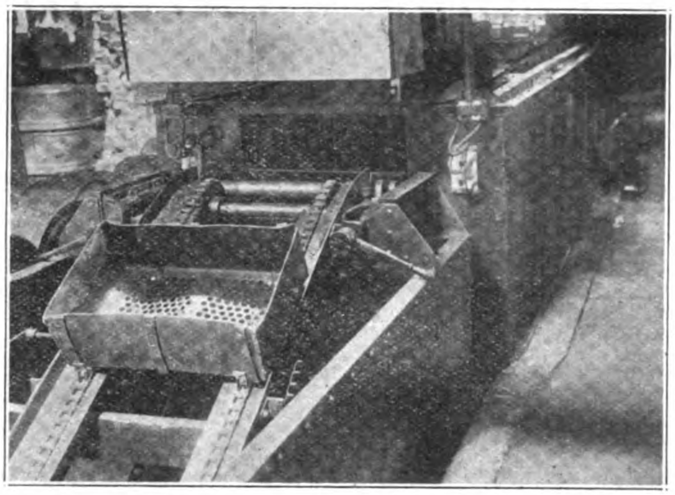
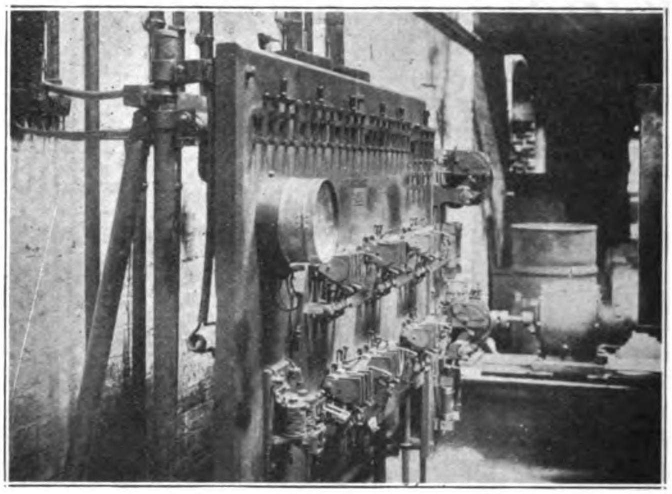
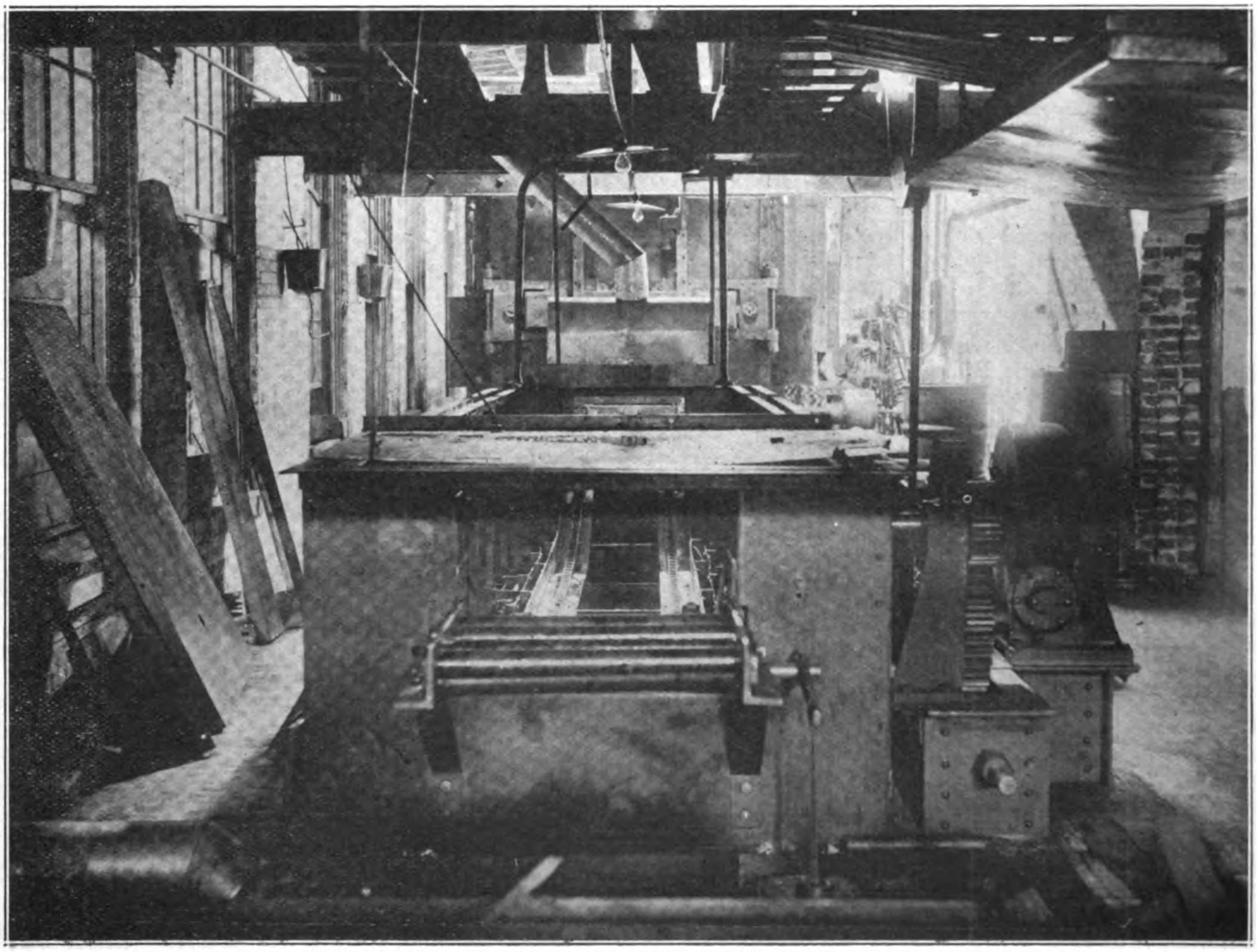


Taking the material from the oil quench into the drawing bath.



The control panel for regulating the heat treating operation.

A motor operated centrifugal pump started when the doors open, forces oil up through the perforated bottom of the tray with almost sufficient force to float the rings, the object being to chill the rings quickly and to prevent the formation of vapor films or pockets around the heated stock. The length of time the trays remain in the quench is determined by the setting of a small synchronous motor timing element by means of which the quench tank can be varied from 1 to 4½ minutes. At the expiration of this time, the tray is removed from the quench by means of a motor driven inclined sprocket chain, the tray draining until another operation of the furnace, when a further movement of



Discharge end of the drawing bath.

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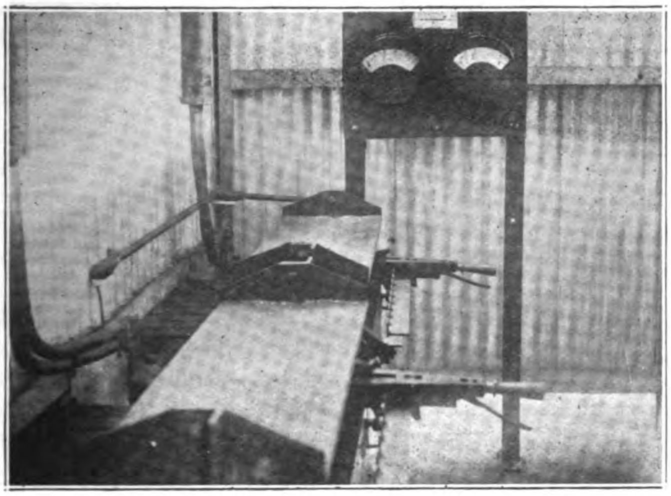
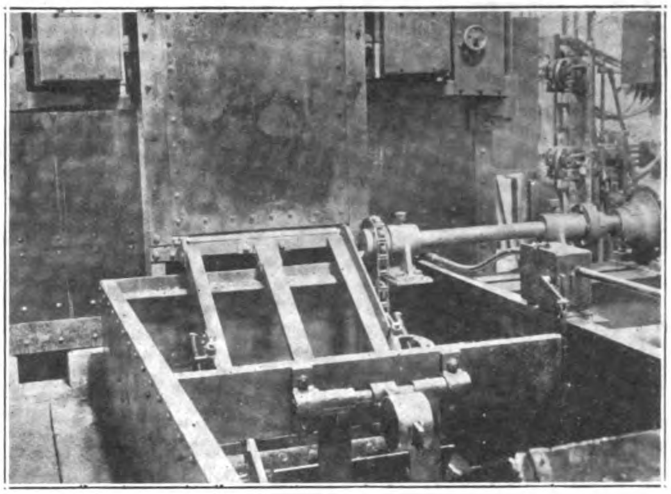


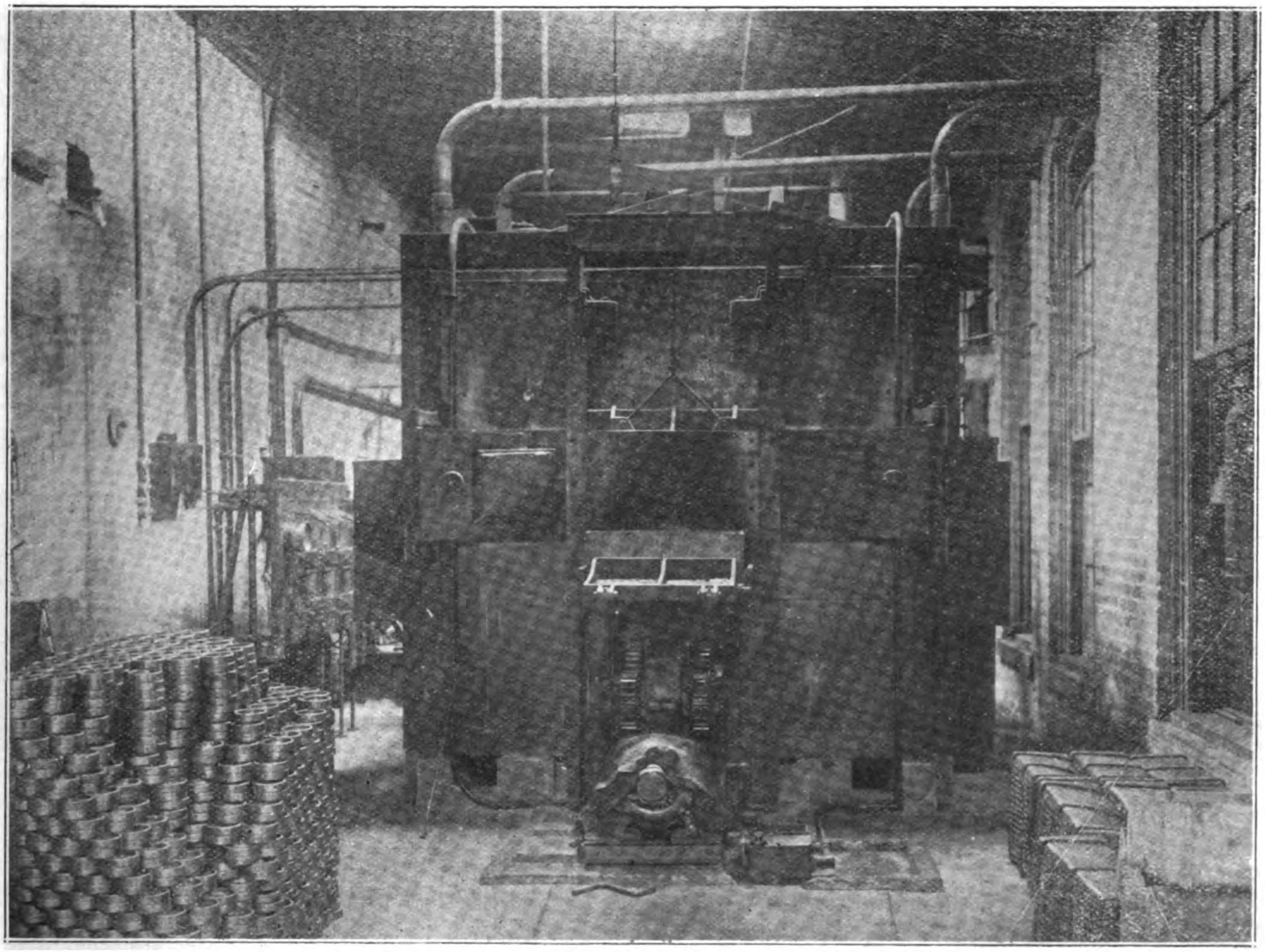
View of oil brake switches.



Discharge end of the pusher furnace into the oil quench.

the chain feeds the tray into the draw tank. The trays move slowly and continuously through the draw tank carried on an independent sprocket chain which is in turn supported on steel guides. The time required for a tray to pass through the draw tank can be varied by change gears very similar to the change gears of a lathe.

This arrangement thus gives an exacting control of both time and temperature and is so flexible that it can be quickly changed to fit almost any schedule or conditions required in heat treatment. The entire furnace and the equipment as described above and was designed and built by the Electric Furnace Company of Alliance, O.



Pusher furnace showing platform. The ball races which are heat treated are shown at the left.

Heating Furnaces and Annealing Furnaces

Proper Heating With Low Fuel and Labor Costs the Main Objective in Furnace Operation—Points Out Present Status and Future Avenues of Improvement in the Industry.

By W. TRINKS.

PART XIII.

THE ultimate purpose of any heating furnace or annealing furnace is the proper heating of some material at the minimum cost per unit weight of heated material. The accent rests on the words "proper" and "minimum cost." No reduction in cost will avail, if the quality of the product suffer; and competition will be difficult if quality can be obtained only with excessive cost.

In this article the author has somewhat deviated from the logical trend of this series in order to review some of the past developments in heating furnaces and annealing furnaces and to make some suggestions as to future developments. Thus this article carries out the plan of the entire number in reviewing technical advances. The trend of the series will be resumed next month.

The present installment aims to give a bird's-eye view of what has been accomplished, and a brief outline of what remains to be done.

Turning first to the consideration of proper heating, we readily see that it involves uniformity of temperature with regard to space, controllability of temperature with regard to time, and freedom from chemical reaction between flame and stock (material being heated). The higher the furnace temperature, the easier it is to maintain space uniformity of temperature, because at high temperatures even small temperature differences cause vast differences of radiant energy which result in speedy temperature equalization. In high temperature work (2,200 deg.), heat transmission into the surface of the steel is much more readily obtained than heat penetration within the steel. For that reason furnaces of the combustion type are very satisfactory for high temperature work in spite of their tendency to localize the heat. In low temperature work, a well-designed electric furnace gives probably the best results, because resistors can be placed all around the material which is to be heated, and can readily be maintained at the desired temperature. In combustion furnaces, low temperature work causes difficulty because all flame temperatures lie above the kindling temperature of carbon. As soon as uniform temperatures below that value are to be maintained, we must turn to the expedient of balancing heat inflow versus heat outflow at the desired temperature. Fig. 90 shows in a diagrammatic manner how this method works; it also shows that uniformity of temperature can be approximated, but can never be completely attained. The larger the pieces or the pile of pieces to be heated to a low temperature, the lower that temperature (down to about 600 deg.), and the smaller the heat conductivity of the material which is to be heated, the greater are the difficulties of maintaining a uniform temperature.

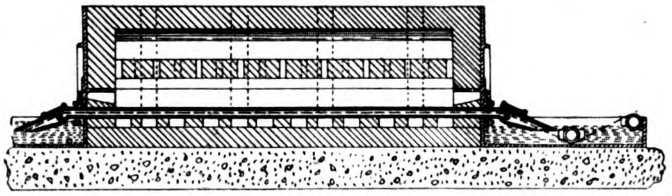


Fig. 91.

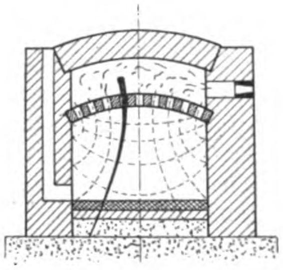


Fig. 90.

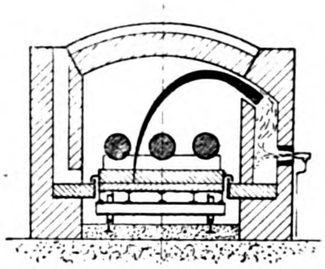


Fig. 92.

The problem can be solved by diluting the gases of combustion with sufficient air to reduce this temperature to only a little above that of the stock, which latter must then be enclosed in a muffle to prevent oxidation. The muffle may be dispensed with, if steam or flue gases are used to depress the temperature of the hot gases of combustion; but, as far as I know, furnaces embodying this principle have not been built. Steam has, however, been used for maintaining an inert atmosphere in the bright annealing of copper wire. In Fig. 91 the wire

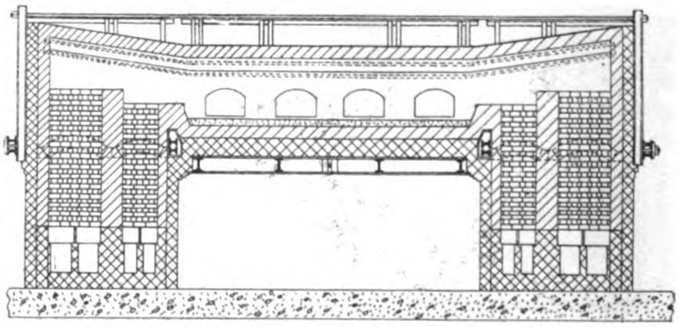


Fig. 93.

enters the muffle through a water seal, and leaves it through a water seal.

The maintaining of uniform temperature causes difficulties not only in the above-described cases, but also in many others, for instance in car type annealing furnaces. See Fig. 92. No matter whether these furnaces are direct-fired, side-fired, or over-fired, the hearth (in this case the top of the car) is cold, and there is a severe temperature gradient from top to bottom, particularly in the center of the furnace, that is to say, midway between the rails. If the material which is to be annealed is charged in one layer only, the temperature is uniform enough for good results; but, as a rule, plant superintendents are anxious to increase furnace capacity by charging several layers. The results are almost invariably disappointing, which fact has led to the design of cars with cavities in the tops, through which the gases of combustion must pass on their way out of the furnace. It is, of course, difficult to make the hollow car tops as rugged as the solid ones, and for that reason the former have not become popular. For the same reason, auxiliary burners firing into ducts in the car tops have not gained a foothold.

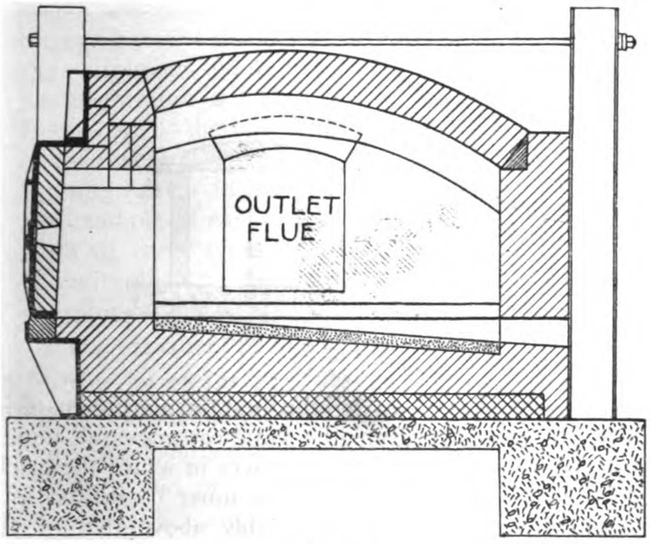


Fig. 94.

The maintaining of a uniform temperature in a horizontal plane is less difficult, particularly if many small burners can be applied. With many fuels such as raw producer gas, coal on grates, powdered coal, etc., such an arrangement is not possible, and then the skill of the furnace designer is called upon to distribute the heat as evenly as possible by all sorts of tricks. Among them are: (1) Change of direction of flame travel by reversing. See Fig. 93, which illustrates a bridge furnace. This method gives sufficiently even temperature for three-door and four-door furnaces, but fails for extra long furnaces. (2) Slanting of roof and offsetting of flue to crowd the heat over toward the door, see Fig. 94. (3) Delayed combustion. Additional methods will be discussed in later installments.

The quality of the product is also affected (at least in many cases) by the nature of the flame. A neutral flame is desired in most furnaces. It can most easily be obtained with gas as fuel (see Nov., 1919, and Dec., 1919, installments of this series); oil and tar cause some difficulty, while coal on the grate is almost hopeless. The difficulty with oil and tar lies in the change of viscosity produced by variation of temperature and of chemical composition. Up to the present time no simple device has been contrived to automatically take care of that variation. With coal on the grate the flame is either strongly oxidizing, or else very smoky. Controllability of flame with regard to time is likewise obtained with gas, oil and coal in the given order. With constant-quality and constant-pressure gas it is easy; with oil, we need a watchful operator, while, with coal, the temperature and the composition of the flame vary widely. Mechanical stokers improve the situation, but not as much as operators desire. Proper heating with minimum cost involves both fuel economy and labor economy. Praise is due to the designer and operator who can combine all three factors, namely; proper heating, fuel economy, and labor economy. Altogether too often two factors are favored at the expense of the third one.

Fuel economy involves low heat losses. The latter are radiation and convection losses, stack losses, heating of material other than the product. To this must be added, in combustion furnaces, losses due to incomplete combustion and due to flames escaping from the furnace, while in electric furnaces the stack loss is replaced by loss in the external resistances.

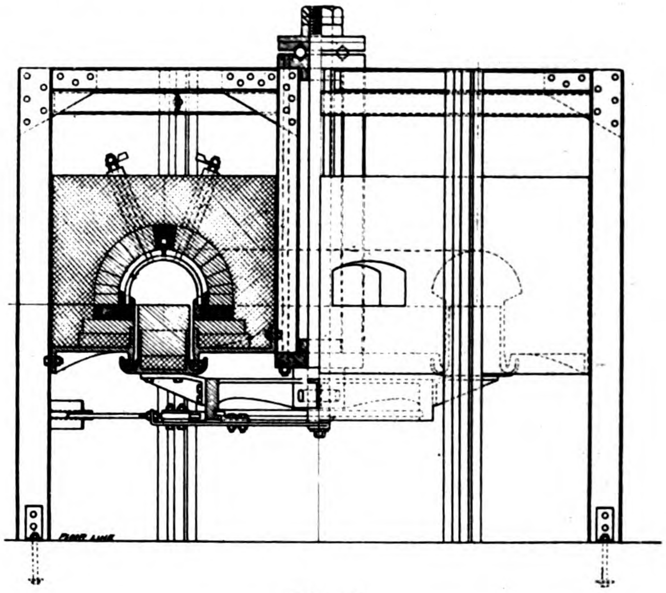


Fig. 95.

As previously explained, (part 10) continuous furnaces with recuperation are the most economical type in existence. Unfortunately, this type of furnace is limited in its application. For heating billets to rolling temperatures it has been brought to a high state of perfection. In these furnaces radiation and convection losses are minimized by circulating air for combustion over the roof, through a recuperator, and under the hearth. The ratio $\frac{\text{heat in the steel}}{\text{potential heat in the fuel}}$ has come close to 70 per cent in a few installations. The principal loss in this type of furnace is the rapid flow of heat into the water-cooled pipe skids. Doubtless, means will be found to get along without water-cooling them. Chrome steel rails leading on to magnesite hearths are now in use in many furnaces. Rails with inserted tongues of high speed steel have been proposed, and in one Pittsburgh steel plant the pipe skids have been replaced by a solid cylinder consisting of a mixture of magnesite and chrome ore. It was hardened and glazed by a wash heat, and has stood up quite well (according to information given by the heater).

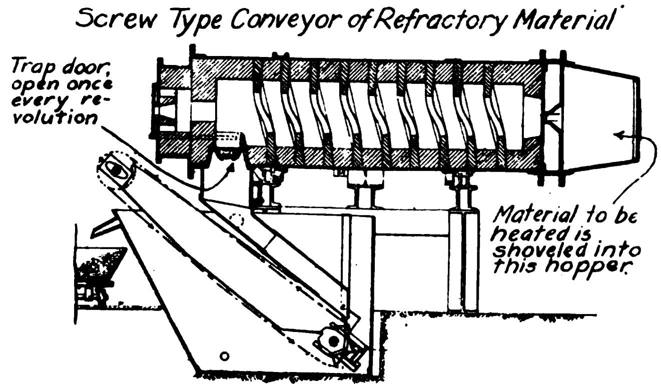

Screw Type Conveyor of Refractory Material
Trap door, open once every revolution
Material to be heated is shoveled into this hopper

Fig. 96.

Additional improvement is possible in recuperators by making their high temperature end of a high heat-resisting metal, or a combination of metal and refractory. Patent protection has been secured on such a design.

Where the shape of the pieces to be heated precludes the use of continuous furnaces, fuel economy is frequently secured by regenerators (see Fig. 93). As explained in part 8, the rate of heat transmission in regenerators is limited by the available draft, both on the entrance side and on the discharge side. While draft, and with it the heat transmission, can be increased by the use of fans, the application of the latter means a thorough change in design, if the full benefit of the fan draft is to be obtained. It is doubtful whether engineers are ready to take this step.

Considerable fuel is now wasted from heat losses through the walls and roofs. In high temperature heating furnaces for rolling mill work, forge and drop forge work, it is customary to use 4½- or 9-inch firebrick roofs without any insulating material. Silica brick cannot be used, because the temperature changes are too severe in starting up and in shutting down. In a thin firebrick roof the inner layer may be dripping hot, but it is backed up by a rigid, cooler layer; while in a thick, insulated roof, the softening extends more deeply into the brick and the dripping layer is burned away. In a few furnaces the heat passing through the roof is utilized for preheating combustion air, but in the vast majority of furnaces it is wasted. For that reason, it is very desirable that a refractory be made which will stand temperatures of 3,000 deg. F., and will not spall with sudden temperature changes. Some of our American fireclays come so close to this specification that a little care in selection and burning should give the trade a firebrick which will permanently stand a 2½-inch insulating layer over the roof of the combustion chamber. Tests in this direction are very much to be desired.

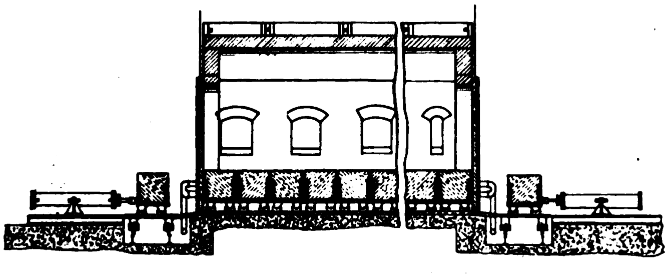


Fig. 97.

In annealing furnaces and in hardening furnaces, it is usually necessary to heat up the furnace with the material and then to cool the two together. This method is extremely wasteful if the mass of the furnace is great compared with the mass of the stock. A similar condition exists in heating furnaces for large ingots in which the furnace is cooled down from 2,200 deg. to about 1,500 deg., in order to protect the cold ingot from the uneven heating. The solution for the latter case lies in preheating pits. Red hot ingots can be put into a white hot furnace without injury to the ingots. The solution for the former case lies in very thin firebrick walls in the furnace, backed up by the best insulating material which is obtainable. Into the same category fall underfired, side-fired or over-fired furnaces in which the brickwork of the combustion chamber must be heated to a temperature which lies considerably above that of the heating chamber. For such furnaces the dividing partitions should be made of materials of high conductivity, such as carborundum bricks.

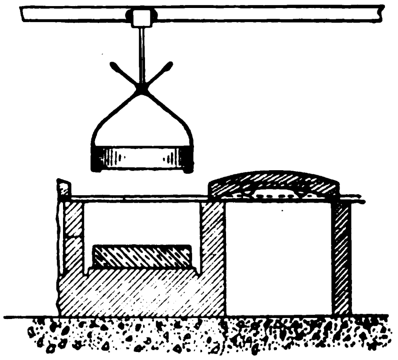


Fig. 98.

Flame control, mentioned under proper heating, is of essential importance for fuel economy. Proper flame control means careful attention to the details of temperature and of pressure both for gas and for air. The viscosity of oil or of tar must be watched, if liquid fuel is used. Altogether too often the control of these quantities is put into the hands of unskilled, foreign labor. Automatic temperature control has been attempted, but has not been adapted to any extent.

In the determination of the cost of production of unit weight of the material heated, the first cost of the furnace installation must, of course, be taken into account. And that is where fuel economy and first cost clash. Regenerators, recuperators, large continuous furnaces, preheating pits, and other fuel-saving devices run into considerable sums of money. The place where interest and taxes on, and repairs and maintenance of the added fuel saving equipment, when balanced against the saving of fuel, still leave a considerable margin in favor of the latter, fluctuates with the price of labor and of fuel. Unfortunately, there exists today no published price of cost of recuperators per square foot of heating surface based on a labor index factor. In consequence, each individual case requires a separate and tedious calculation, or else a guess based upon previous experience. Much unnecessary brain work could be saved, and much better balanced furnaces would be installed, if reliable cost information compiled in the proper manner were available. However, the work of compilation is so great as compared to the compensation which any individual could possibly receive from publication of the data, that there is very little hope of the work being done.

The problem which comes to the front more and more every day is labor economy in charging and emptying the furnace. For that reason, continuous processes with mechanical conveying of material are being favored wherever possible, even if these processes should involve a slight loss of fuel. Examples are continuous billet furnaces, continuous sheet bar furnaces, continuous sheet annealing furnaces (Costello type) in which the sheets are carried on rollers through the furnace, rotating hearth furnaces. Many difficulties confront the engineer who attempts to move odd-shaped pieces through a high temperature continuous furnace. In this work there is still much room for the ingenuity of the inventor. The best compromise is today offered by rotating hearth furnaces and by rotating drum furnaces. An example of each type is shown in Figures 95 and 96. Both of these types are full of the "cussedness of inanimate objects" and are apt to give their designers and operators some weary hours.

The expedient of moving objects through a continuous furnace by means of a chain has been tried repeatedly, but has as a rule, been unsuccessful. Chains oxidize, they also lengthen under the combined influence of temperature and pull, they climb up on the sprockets and soon become inoperative. For low temperature work, (up to 1,600 deg. F.) chains of Nichrome meet with success, but are expensive. Pawl and ratchet devices are likewise used with success in low temperature work. Chains are successfully applied to moving objects through a furnace in such a manner that only a part of these objects projects into the furnace. In such a case, the chain proper stays comparatively cool.

Car type furnaces have been quite a favorite with engineers, particularly for heavy materials. Figure 97 illustrates the principle of a continuous car type furnace. They have two drawbacks, namely the heat which each car takes out of the furnace, and the work connected with bringing the car back from the delivery slide to the charging side. The former drawback can be obviated by recuperation (as in the Dressler tunnel kiln).

Bung type furnaces reduce the labor of charging and emptying, but are, as a rule, wasteful of fuel. Figure 98 illustrates this type.

In many cases, the cost of labor per unit of material heated can be reduced by changing from coal to oil or gas. However, this statement must not be generalized. There are cases in which only little fuel is used, and in which the heater has sufficient time between his other duties to throw a few shovels of coal on the grate.

The present installment has been sketchy. By its very nature, viz.: that of a review of past developments, and a prophetic outline of future development, it necessarily had to be sketchy. But one truth stands out from the kaleidoscopic picture, namely this: the first cost of furnaces which produce high quality product with high economy of fuel and labor is and will always be high. While, in the past, low fuel prices have prevented the general adoption of high priced furnaces, present fuel prices and the probability of future still higher prices put a different aspect on the situation. High class furnace engineering will soon be the rule instead of being the exception.

In the next installment the regular logical trend of this series will be resumed.

Heating Furnace Fuel Progress During 1919

Fuel Situation Gives Impetus to Study of More Economic Combustion Methods—Inefficient Use of Natural Gas Should Be Discouraged—Improvements Suggested.

By A. E. BLAKE.

THE beginning of 1919 found the steel industry in the slow process of readjustment from conditions imposed by the war. Many governmental restrictions continued. Much uncertainty as regards export and domestic demands existed. Politics have seemed to be responsible for much that was depressing in the situation. During the summer months, the outlook seemed to brighten for a few weeks, but the anticipated return to feverish activity and generous expansion in all lines was quickly blocked by developments in the labor situation which gave early indication of becoming troublesome. The effects of the labor strikes are known only too well. Some of our largest mills have been running upon a "hand to mouth" basis for months, ordering their purely necessary requirements and those only in lots sufficient for a fortnight of operation.

Many furnaces used for war work have passed out of existence. In a few cases, certain of them have been adapted to other purposes. Beyond doubt, many manufacturers have had their attention drawn in such forceful ways to furnace design and furnace efficiency, and to methods for heating furnaces that the lessons learned will be of permanent value. Fuel shortages

and prices are giving the same accelerating influence that they did during the war, and operators are finding more time to devote to the subject than they did when war production was at a maximum. The formation of groups among the manufacturers of the various classes of munitions has undoubtedly proved beneficial in calling attention to the vastly improved methods of firing which have come into common use within the last six years in this country.

Not the least of the manufacturers' worries has been the natural gas situation. While there is not the slightest doubt that the dealers in this ideal fuel are convinced that enormous quantities of it are wasted, and that many of their consumers should be prohibited from using many of the furnaces which they do operate and with waste of fuel which is nothing short of criminal, the demands of business make necessary a policy which can be summed up by the observation that the gas business seems to demand the passage of natural gas through the meters of the customers at the maximum possible rate. Furthermore, it is true in many cases that attempts on the part of some of the gas producers to assist consumers did not meet with the approval and coöperation of the latter. It seems very likely that competitive drilling and selling is responsible for much of the waste. Intelligent regulation of drilling, and of distribution by rigid and competent authority, applying to all producers alike, ought to go far toward solving the problem. It is difficult to understand why so important a conservation problem has so long escaped adequate attention. The only manner in which business considerations seem able to promote efficiency, so far as the gas companies are concerned, is in a none too gradual increase in the price of the commodity. This latter feature, together with the necessity for oil auxiliary firing equipment has not been pleasing to manufacturers, many of whom have installed artificial gas making apparatus, or oil firing equipment only.

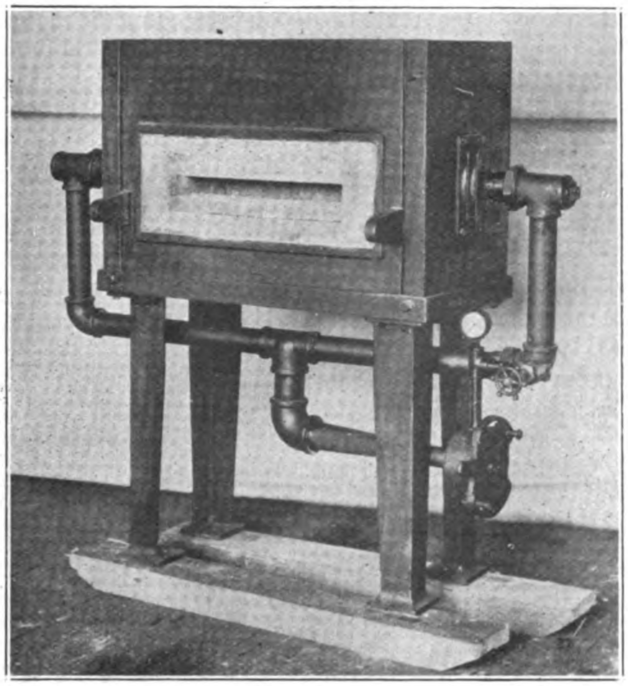


Fig. 1—Forge furnace.

The price of oil fuel became remarkably low during the dull period in manufacturing, giving much encouragement to those who had been contemplating the use of that fuel, but prices have advanced again to a point where gas is by far the cheaper fuel.

Gas shortage has caused increased use of coal in many operations, as might be expected, where the work is of a rough nature, requiring no attention to the matter of uniformity, sulphur scale, and dirty factory conditions. The burning of raw coal has, on more than one occasion, been pronounced an act of barbarity, and is prohibited in several European countries. It is reasonable, therefore, to regard its use as temporary. The waste of the available by-products is a matter which ought not to escape prohibitive action in this country before long.

The attitude of manufacturers toward unfamiliar methods is not, as a rule, to their credit. They seem regrettably unwilling to follow the recommendations of their own engineers, also to hold the latter so rigidly responsible that nothing short of absolute certainty of success will induce the engineer, often an expert in his line, to make a recommendation. The lack of fuel experts upon the engineering staffs of many large concerns is often noticeable. Such experts are not easy to secure. It seems a pity that the research physicist and chemist has not been employed in this field in greater numbers. It has been a pleasure to note the selection of several men from the United States Bureau of Mines staff for fuel efficiency work. It is to be hoped that such men will receive the greatest possible latitude.

In spite of the unfavorable conditions, several interesting developments have occurred in furnace practice which will be interesting to the steel industry.

The engineers of a large steel company in Ohio, wishing to satisfy themselves as to the possibility of operating a large continuous pusher type slab heating furnace by flameless firing with coke oven gas, made up a crude set of apparatus for accomplishing their object, and proved to their complete satisfaction that the usual long luminous flame which commonly trails into a stream of soot at the cold end of the furnace, is unnecessary. The logical result of this experiment awaits the disappearance of labor troubles.

The campaign against the inefficient use of natural gas has made an enormous step in the past two months. A steel company in the Pittsburgh district applied the most approved system for firing flamelessly, embodying perfect automatic one-valve control, to one of its sheet heating furnaces in the sheet rolling department. The ordinary method of using gas termed the "lazy flame" method, and involving the maintenance of a virtual sea of flame within, and the use of very insufficient amounts of air for combustion in order to prevent scale formation, was superseded by the method which insures a perfectly homogeneous and accurately proportioned mixture of air and gas in the correct ratio for the production of a furnace atmosphere containing a slight constant quantity of carbon monoxide. The air necessary for combustion is supplied at about one pound pressure per square inch, and the gas may be supplied at any pressure between one-half ounce and eight ounces. The proportioning of gas to air is fixed, requiring no attention from the operator, who merely varies the rate of air supply when wishing to change the rate of heating. The furnace stack has been rendered useless. The former bridge wall has been bricked up to connect with the arch in each of the three chambers. The furnace interior is perfectly clear.

Analyses of gas samples taken from the chambers showed complete absence of free oxygen. The difference in fuel requirements between this furnace and one beside it using flame is 60,000 cubic feet per 24 hours, when the same amounts of work are being heated to the same temperature. Six new sheet furnaces, and the same number of pair furnaces are now being built which are to have no fore-chambers or stacks. Owing to the use of adequate insulating material, the fuel consumption per furnace is expected to be still lower in comparison to the results already obtained.

The operators of the altered furnace report that much labor is saved them, due to uniformity of temperature in the work. They are able to work for hours without resetting their rolls. A continuous sheet annealing furnace, having an automatic stoker for coal firing, is being fitted to use gas by the system described. Provision for coal firing will not be removed.

The use of the automatic proportioning system is gaining very extensive use in every class of hot galvanizing. One concern recently installed a kettle with apparatus guaranteed to require less than 750 cubic feet of natural gas per ton of steel sheets while producing 52 tons per 24 hours. The common requirements in the past have amounted to about 1,750 cubic feet per ton. Such operations can best be covered by experts who have made a painstaking study of them, and then only when the full coöperation of the operators can be had.

The purchasing department of one of the largest manufacturing interests in Western Pennsylvania has issued permission to its operating departments to use fuel oil at will. This has been due to failure by the latter to secure proper economy and the proper temperatures for forging and welding with natural gas. The antiquated equipment used is practically all of one make. In order to show the fallacy of the belief that oil is superior to gas, the following substance of a report from the Chicago district is used:

An ordinary forge furnace fired by artificial gas ot 580 Btu, having a working slot 24 inches long, was found to be able to heat 300 seven-eighths inch rods per hour using 1,000 cubic feet of gas. With gas at 65 cents per 1,000, the cost of this work was practically the same as when oil was used. A smaller furnace was installed, however, with an 18 inch slot, Fig. 1, using the same principle as outlined above, for heating without flame. This smaller furnace heated 336 rods per hour of the same size and to the same temperature with 660 cubic feet of gas per hour. If the gas used could have been natural gas, the consumption would have been about 510 cubic feet per hour.

In the same connection, glass houses using the automatic flameless system operate direct fired melting tanks at 2,800 degrees F., and an outfit is being installed to operate at 3,000 degrees F., using coke oven gas.

It has been shown recently, to the surprise of many steel makers, that electric steel furnaces do not usually operate at temperatures above those common in the open hearth. The refinement of electric melting compared to open hearth practice needs no comment. Indications are, however, that gas is as suitable for use in the making of high grade alloy steels as is electricity. Already a very small flameless testing furnace has been placed upon the market for laboratory use, Fig. 2, which is designed to reach 3,600 degrees F. with ease, using any gas which is 90 per cent combustible. This will be of assistance to the metallurgist in fusion testing, in the study of high temperature critical points, and in the preparation of small samples of alloys having high fusion points. The use of properly designed furnaces of this type, and of much larger size will certainly be attempted in the production of alloy steels, because of the absolute certainty as re-

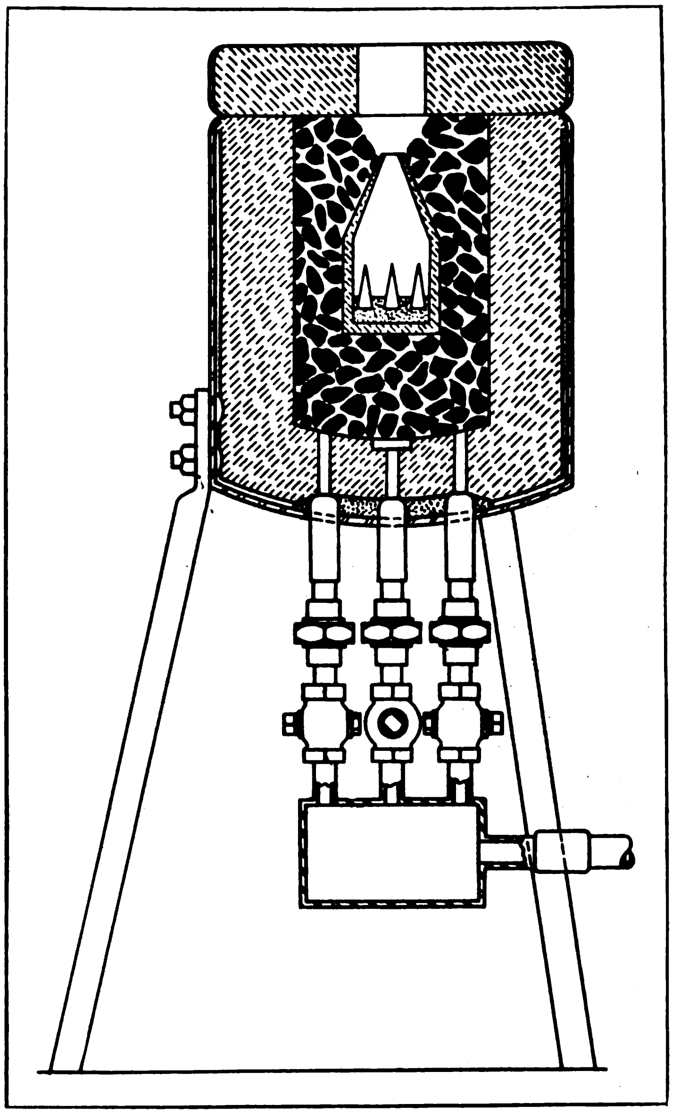


Fig. 2—Laboratory Furnace.

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gards control of atmospheric conditions within the crucible, insofar as they may be governed by combustion, and because of the very small gas consumption of this type of furnace.

Flameless combustion has been applied to the wire patenting process with results so satisfactory as to create a steady demand for furnaces for that duty and so equipped. Scaling of wire has been reduced to less than 0.5 per cent.

A muffle furnace fired by the flameless method and used for bright annealing non-ferrous metal wire was recently operated through carelessness after the muffle had been removed for repairs. It was found, however, that the metal was as bright as any ever produced. The discovery is being put to good use by several large concerns.

In closing, it seems necessary to remark upon the serious lack of record tests of fuel consumption for the various furnaces to be found in many plants, and still more upon the lack of any meter for making such tests. This is a result of the former low price of natural gas, and it should be remedied by all means unless the operators are willing to place trust in unsupported claims of dealers, when purchasing firing equipment. The wholesale waste of gas which occurs today in many of our plants, due to ignorance, prejudice, misrepresentation, and carelessness will certainly be halted; whether to the detriment of the consumer or not, will depend upon circumstances.

Continuous Sheet Galvanizing Furnace

Description of New Sheet Galvanizing Furnace Installed at the Apollo Steel Company, Which Represents Considerable Fuel Saving Over Previous Furnaces.

By A. E. BLAKE,
Sales Engineer, Surface Combustion Company.

THE Apollo Steel Company, Apollo, Pa., has just placed in operation a continuous sheet galvanizing installation designed by the Surface Combustion Company. Because of the numerous vital points requiring careful attention in the process of hot galvanizing, such installations are usually given a wide berth by the ordinary furnace manufacturer, particularly when the latter are called upon for rigid guarantees as to fuel requirements and successful operation. Owners and operators of galvanizing kettles have usually developed their own installations in accordance with certain general features and with the particular conditions existing in their plants. They generally seem to feel that if a kettle is in successful operation, one has good cause for contentment.

Galvanizing, however, is one of those heating problems which lends itself to solution with little difficulty when attention is paid to detail by one who will take note of the technical and scientific facts involved and apply them logically.

In the matter of making improvements in any sort of furnace practice, the logical mode of procedure, suggests itself: (a), a careful investigation is made with a view to ascertaining the exact nature of the work called for, the existing practice, the degree of success realized, the surrounding conditions having influence in the case, the fuel consumption, the life of the equipment, and the attitude of the owners and operators; (b) a careful study of the information gained, in the attempt to discover if the product can be improved in quality, whether the methods used are the best possible, whether production can be facilitated or increased, if local conditions can be improved, if fuel can be saved, if the life of the equipment can be prolonged, and if the work of the operators can be made easier; (c) a careful preparation of specifications for a new installation, or for alteration of an old one, with the view of creating the greatest possible measure of satisfaction to the owner by eliminating as many of his difficulties and as much of his cost of production as possible.

The work called for in the case of the installation to be described was the galvanizing of 52 net tons of sheets, of from 14 to 30 gauge, in 24 hours. The existing practice produces work which has long been recognized as of the highest grade, and the owners are pioneers in the field. The fuel used is natural gas. Firing was accomplished by the use of induced air for combustion. Natural draft from a stack was employed. The gas consumption was given as 1,750 cubic feet per ton output. The life of the kettle has been from 8 to 12 months. No particular difficulties attracted attention or received mention. The foregoing information, therefore, served as a basis for study.

The new kettle, which measures 86x86 inches and 44 inches deep, was installed and placed in operation in December, 1919. The following is reported by the galvanizing foreman after a few days of operation: Owing to the shortage of steel, it has not been possible to operate the kettle to full capacity. Twenty-one tons of No. 24 gauge sheets have been galvanized in 11.5 hours with a gas consumption of 800 cubic feet per ton. Inasmuch as the holding consumption, or the heat losses through the furnace walls will remain practically the same, whether the rate of working is fast or slow, it is beyond doubt that the predicted figure of 750 cubic feet per ton will be realized as soon as production is increased to normal.

The nature of the firing equipment and its application is as follows: Each side of the installation is provided with a battery of burners suitably manifolded and spaced. Each of these batteries is under separate control and their individual rates of operation can be adjusted to suit the requirements, whether these are for working rapidly or slowly, or for merely holding the bath molten. Manifold gauges, however, enable the operator to duplicate any given rate of firing for each battery.

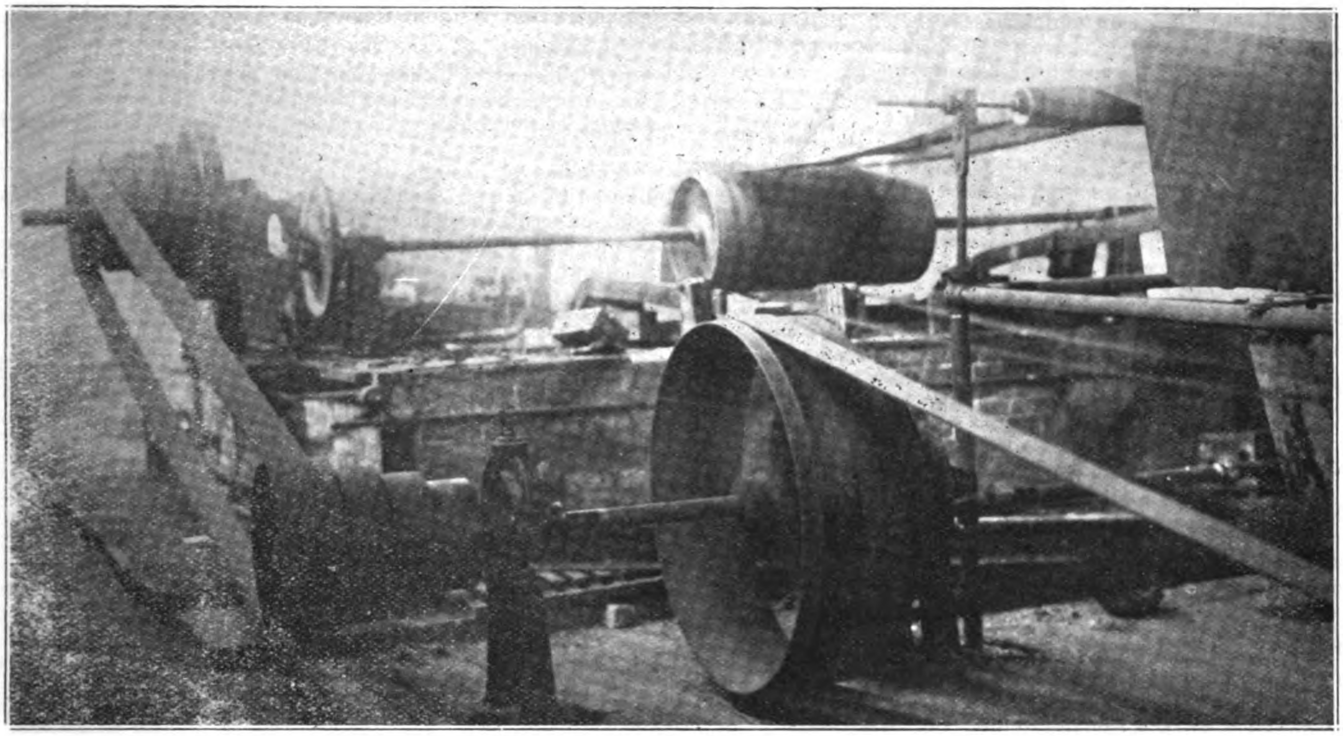
The burners are cemented closely into the walls which consist of firebrick suitably insulated and retained. Air space between the brick walls and the burners is not desired, since cold air should be prevented from entering the firing chamber to cause lowering of the temperature. On the other hand, furnace gases cannot find exit at the burner inlets, but must leave by the flue holes provided. The burners direct streams of completely mixed gas and air in the ratio for theoretically exact combustion, into pocketed beds of highly refractory material, at the bottom of the heating chamber. The refractory material is separated from the steel kettle by a tile of suitable height and thickness.

The mixture penetrates the refractory for a certain distance, in reaching a zone where the flow-rate equals the combustion rate for the mixture employed. Within this zone, the entire reaction takes place at the greatest practical speed and the resulting products of combustion liberated within the smallest space and in the shortest time, contain the heat set free at the highest possible intensity. After the refractory bed has absorbed enough heat from these gases to practically equal them in temperature, they issue from the highly incandescent material under the most favorable circumstances for giving up heat. The difference in temperature between them and the sides of the kettle is far greater than that possible when flame heating is employed, therefore the rate of absorption will be greater in proportion. When the chemical reaction which liberates the heat is completed wholly within the refractory bed, no further combustion or flame is possible above it. One might say that all the heat to be used is mobilized at the outset and commences then to accomplish its work. Thus the time afforded for the products of combustion to remain in the chamber and give up heat is greater than it can be in the case of flame heating where it is difficult indeed to prevent the reaction from extending into the flues. Elimination of flame contact with the steel is a very important feature.

The incandescent bed is a very valuable adjunct in the transmission of energy to the work. Because of its refractory nature, its incandescence can be made to exceed that of any flame the furnace walls or the kettle would tolerate without injury. The radiant energy issuing from the refractory is more readily absorbed by the steel than the heat from the gases within the furnace, and absence of dull flame and soot permits full benefit to be realized. It has also been demonstrated by the early workers in surface combustion that the incandescent surface of the granular refractory exerts much influence to increase the rate of gas reaction. These facts all assist in the production of large amounts of available energy with small amounts of gas.

One must easily realize the importance of an adequate supply of correct mixture. This is obtained from a patented automatic proportioning device which re-

(Continued on page 128.)



View of continuous sheet galvanizing furnace.

FOREIGN RELATIONS

RENEWAL OF GERMAN STAHLWERKSVERBAND.

[From the Economisch-Statistische Berichten of Essen, transmitted by Trade Commissioner Arthur H. Redfield, The Hague, Netherlands.]

The German Stahlwerksverband, formerly a powerful body which embraced the manufacture of semi-manufactured iron and steel, railroad material, and profile iron in Germany and Luxemburg, found itself in a serious situation, in part, as a consequence of the misfortunes of war, whereby Germany lost Lorraine with its minette ores and the principal German blast furnaces, and the customs union with Luxemburg was abrogated; while important centers of the iron industry were occupied by Allied troops, and the fate of Upper Silesia, with its significant industries, was left undecided.

Naturally, the largest German steel mills entered this organization with the intention of securing an easier development of the industry than would have been possible had each plant worked independently. It was rightly feared that if the contract which bound the plants to the association was not renewed, a titantic struggle of the mighty industries with one another would ensue. Against foreign competition the Stahlwerksverband was powerful, though it cannot be said that it accomplished miracles in the conquest of world markets. Credit for successes in this field must be given to the subsidiary organizations of the individual members. During the war, the Stahlwerksverband was nursed along. Most of the member concerns had been able to develop and extend their activities by their own efforts, and, when extensions of the association were up for consideration, they made demands for participation in the benefits in proportion to their increased productive capacity. The other enterprises would not assent to this. The consequence was that the extensions of the organization were made for short periods—a year or six months—and sometimes were provisional. This took place under the pressure of war and a compulsory government-instituted syndicate prevented members from withdrawing.

Withdrawal of Member Owning Mines in Alsace-Lorraine.

On July 1, 1919, the provisionally extended contract once more expired. The Gelsenkirchener Berwerks Aktiengesellschaft, which owned large ore mines and blast furnaces in Luxemburg, negotiated for the sale of these properties and withdrew from the organization, since after this sale it could no longer manufacture the so-called A products. Moreover, the steel industries of Alsace-Lorraine sought affiliation with the Belgian-Luxemburg and French groups; so that these could no longer be counted upon for further membership in the Stahlwerksverband. A further renewal of this association was doubtful. In order to lose no opportunities, it was resolved not to sell individually until August 1. Indeed, the directorate of the association had resolved, since the limit of paid-up shares was no longer attained, that the members could sell freely within the limits of this figure, as far as concerned semi-manufactured forms. In case of railroad material, in which the government was especially concerned, delivery was still to be made to the association. On account of the unsatisfactory situation in raw materials and fuels, the question of participation in the benefits of the association created no difficulty in the way of a renewal. When no agreement could be reached, the association was once more provisionally extended.

At a recent general meeting of the Stahlwerksverband it was resolved to continue the organization until the end of 1919, if the absent members should give their approval to this resolution. All of the latter have given their assent except the Rheinische Stahlwerke and the Deutsch-Luxemburg. With this, the course of affairs assumed a more serious aspect. The government demanded that a decision be made before August 20; and further expressed its desire to have included in the Stahlwerksverband the by-products (bars, plates and sheets, bands, strips, pipes and tubes, wire, etc.) as well. The advisability of this was very doubtful, because for years the impossibility of including these various products under a single head has been evident. Even in one and the same branch of manufacture it has seemed impossible to organize syndicates. Only price conventions and other loose agreements, in which not all of the interested concerns are members, exist today.

Members Sell Without Regard to Association Prices.

In August the government desired an organization in order to control production and prices the more readily. Many concerns were quite content to continue under the banner of the Stahlwerksverband, which sold their goods for them; others were not in a condition to book large orders in foreign lands through their own organizations; and all were limited in their production by lack of raw materials and fuel, and suffered exceedingly under high wages and high cost of equipment. The association could not do anything to remedy this, but it had to look on passively while sales of iron and steel were made at prices far exceeding its fixed prices; in practice, its prices meant little, and the members sold without regard to the association, partly out of greed for gain, partly to make good the costs of operation, which were not officially regulated. The export prices were kept high, and stood in no relation to the domestic prices, considering the rate of exchange and the competition of other countries.

As for the Rheinische Stahlwerke, it was a question whether an association could accomplish more under the changed conditions of the international iron market and competition than could the various enterprises independently. Rheinstahl, however, contracted with Otto Wolf, of Koln, and so was bound; but it was apparently inclined to continue its membership with regard to railroad material. On the contrary, Krupp and other members had no interest in an association for the different products, in the form of the existing Bar Iron Association.

Efficacy of Association—Effect of Dissolution.

The great advantage of the association is that prices are the same for all members, so that sharp competition is prevented. In practice, however, the circumstances of the different members are so different that even a general regulation of prices is of advantage to one group of members and of disadvantage to others. Production costs, in particular, vary. The government could step in with compulsory measures; but it cannot compel concerns which are operating at a loss to continue in business beyond their financial resurces, or hinder them from closing their doors and leaving thousands of workmen unemployed. If the Stahlwerksverband dissolves, it will be because its principal members have dropped out and its scope has become, therefore, very limited, and, further, because it did not fulfill all that was expected of it. But if it is to come to an end, now is the best time, for no great dangers will arise on its dissolution, especially as the titanic struggle formerly feared will fail from a lack of capacity; while a way can be found for the Rheinish Westphalian industries to unite on a different basis from that of the Stahlwerksverband, and with a better organization for foreign trade.

The above is taken from a report which appeared in the Daily Commerce Report.

PRODUCTION TOPICS

PROTECTING TUBES FOR THERMOCOUPLES.

By R. B. Lincoln,*

The function of a pyrometer protecting tube is to maintain an atmosphere about the thermocouple most favorable to its continued accuracy and long life, and at the same time permit the weld of the couple to attain the full temperature of the area or object being measured. In addition to protecting the thermocouple from the chemical or alloying effects of the products of combustion or bath being measured, the tube must also protect the couple from mechanical injury. The conditions met in practice vary so much that no one material is suitable for all applications. The usefulness as well as the expense of maintenance of a pyrometer system are influenced greatly by a choice of the most suitable protecting tube. The tube must protect the couple without it becoming too great an expense item.

The protecting tube should have the following qualities: (1) A melting point well above the highest temperature to be encountered. (2) Sufficient strength through the entire range of temperatures to hold up its own weight and resist such shock and jar as are unavoidable. (3) It must be impervious to the atmosphere or bath to which it will be subject. (4) It must not give off any vapor injurious to the couple. (5) It must not form any oxides fusible below the highest temperature to be measured.

The proper location of the tube in the furnace is almost as important as the choice of material. The tube must be placed as near to the work to be heated as possible. It must be kept out of the direct path of flame, both because that would give too high temperature readings and because partly burned fuel will destroy the tube faster than the quiet products of combustion.

Pyrometer tubes are sometimes buried in the floor or embedded in the wall of the furnace, but usually the lag is so great that the readings are of little use. When rare-metal couples and expensive porcelain tubes are used, there is a temptation not to project the couple far enough into the furnace. Where only approximate results are required, a couple may be projected into a depression in the furnace wall; but for the heat treatment of steel, the couple must be near the work. The tube must always project into a furnace far enough to become fully heated to the furnace temperature. A refractory tube will require two or three times its diameter exposed to the heat to get away from the cooling of the tube by the colder parts. A nickel-chromium tube will require twice that much immersion and a steel tube slightly more than the nickel-chromium.

Neither platinum nor platinum-rhodium are injured by oxidation but both absorb carbon, hydrogen, and many metal vapors at high temperatures. Porcelain, kaolin, or fused silica are about the only substances that may be safely allowed to touch a rare-metal couple at high temperatures. Since "chemists triangles" made of nickel-chromium wire do not injure platinum dishes, it may be that if drawn nickel-chromium tubes could be obtained that the fragile porcelain tubes could be entirely dispensed with, but as long as cast tubes only are available, porcelain must be interposed between the outer tube and the couple. A rare-metal couple must be protected from contamination even when cold, otherwise bits of metal, salt or paint, and charcoal from a wooden bench may become attached to it when cold and later destroy the accuracy of the couple when placed in the furnace.

Porcelain was one of the first materials to be used for pyrometer protecting tubes. The best grades for this work soften at about 1,800 degrees C. and are practically impervious to gas. It is one of the few materials that will not alloy with or contaminate platinum. This material is very brittle at temperatures below 1,200 degrees C., and its high coefficient of expansion causes it to break from too rapid changes of temperature. It is destroyed by fused alkalies or metallic oxides. This combined with its first cost has limited its use to a protection for rare-metal couples, and it is usually protected by an outer metal tube.

Fused silica, artificial quartz, has a very low coefficient of expansion and is much cheaper than porcelain. It is suitable for protecting rare-metal couples subject to sudden changes of temperature. When subject to temperatures above 1,200 degrees C., it undergoes a recrystallization causing it to become cloudy and weak. It finally breaks from its own internal strains.

Thermocouples made of nickel-chromium, known under the trade name of chromel, and nickel-aluminum, known as alumel, oxidize very slowly and maintain their accuracy best when subjected to oxidizing conditions. They fail quickly when subjected to strong reducing conditions and even more quickly when subjected to alternative reducing and ozidizing conditions. These materials, when used in an electric furnace heated by nickel-chromium or platinum wire, usually require no protecting tube. When used in a fuel-fired furnace, probably the best and at the same time most economical protecting tube is one made of nickel-chromium. Tubes made of an alloy of 80 per cent nickel and 20 per cent chromium, known under the trade name of chromel A, are most economical for temperatures between 600 degrees C. and 1,100 degrees C., in gas- or oil-fired furnaces. A cheaper tube is made with somewhat less chromium and an addition of about 25 per cent of iron. This tube will stand a slightly higher temperature than the straight nickel-chromium but lasts about one-half as long at 1,000 degrees C. The life of nickel-chromium tubes is greatly reduced by alternately strongly oxidizing and strongly reducing conditions such as are encountered near the bridge wall of a coal-fired furnace. The tube containing 25 per cent of iron is rather more satisfactory under these conditions than the straight nickel-chromium, but the best solution is to so locate the tube that it will be subjected to a dead heat. Nickel-chromium tubes are very satisfactory as an outer protection for rare-metal couples.

At temperatures around 1,200 degrees and 1,300 degrees C., alundum tubes are quite satisfactory but are, of course very fragile.

For measuring high temperatures in large furnaces, porcelain kilns, and glass tanks, where the conditions are very severe but the change in temperature is very slow, tubes made of fireclay with heavy walls, ¾ to 1½ in. (19 to 38 mm.) thick give good service.

Iron and steel protecting tubes seem to allow furnace gases to diffuse through the walls of the tube at red heats and, when used with nickel-chromium couples, should always be open to the air at the end away from the heat. If the outer end is plugged, the couples will behave very much as though not protected from the furnace gases. I consider it safest to have all protecting tubes open to the air at the end away from the heat. Care should be taken to see that this end is not surrounded by flame or gas from the furnace In the case of a bath of molten metal or salt, the tube should be long enough that neither drops of metal nor salt nor small pieces of charcoal will drop down the tube.

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*Hoskins Manufacturing Company.

From paper read before A. I. M. & M. E., Chicago meeting, September, 1919.

PRODUCTION TOPICS

DIRECT INGOT MOULD MANUFACTURE.

(Continued from page 104)

company under discussion has approximately 2,500 different patterns for moulds ranging between 250 pounds and 163,000 pounds each in weight.

How to Save the Mould.

Very often bad mould practice is the result of irregular casting intervals between heats, or the use of water to hasten cooling and stirring of the mould. The best results are obtained from moulds that receive steel at regular intervals (about four times in 24 hours). When the intervals between heats are too short, the mould does not have sufficient time to adjust itself and properly contract before its elasticity is again under strain. On the other hand, too long an interval between heats is also bad for the mould, as it has to stand a succession of sharp expansion strains which gradually tend to destruction. Unless one can lay his bare hand on the mould and draw it away quickly without danger of being burned, the mould is still too hot to go back into service.

Improper centering of the ladle at time of casting or a leaking or badly fitting stopper often causes the steel to strike the side of the mould, thereby cutting a furrow in it which is likely to cause a 'sticker." When starting to pour from the ladle, the stream should come slowly for the first few seconds until there is a cushion of three or four inches of molten metal in the bottom of the mould, then the stopper may be opened to its full capacity. When the steel is rushed into an empty mould, it strikes the stool with such force, that it digs it out and the splash striking against the side walls of the mould has a tendency to cut it badly around the bottom.

In cold weather new moulds should not be put into service until thoroughly warmed, both inside and out. Investigation of numerous cases of excessive cracking has revealed the fact that this necesssary precaution was overlooked, the moulds having been taken from an outside pile in freezing weather and put directly into service, with the natural result, and the manufacturer is then called upon to explain why the moulds fail to produce satisfactory service.

It is only fair to say, however, that a low average mould life is usually due to circumstances beyond the control of the steel plant superintendent, who is naturally anxious to cut his cost of production by making his moulds last as long as possible.

CONTINUOUS SHEET GALVANIZING FURNACE.

(Continued from page 125)

ceives air at a maximum pressure of about one pound per square inch and causes it to operate a governor, by suction, to admit gas, which is automatically reduced from 8 ounces to atmospheric pressure and made to pass into a common venturi mixing tube through a nozzle. This nozzle is placed in permanent adjustment at the outset to produce the exact mixture desired. By controlling the air valve for each battery of burners, the amount of mixture formed is governed, but the composition of this mixture stays the same. Inasmuch as the usual sole care of most operators is the turning out of their day's work, the importance of removing the necessity for setting this proportion by them, can easily be understood. The men themselves are always very glad to be free from the trouble of using two valves.

There is a very important factor in heating which should not go unmentioned, namely, the effects of excess air in heating furnaces. When burners are used which consist merely of pipe fittings or other hardware, no perfect mixing of air and gas occurs. They enter the furnace stratified and consume an appreciable amount of time in diffusing enough to allow combustion to occur. Such equipment makes necessary the use of varying amounts of excess air, commonly between 15 and 75%. The air is used to overwhelm the gas and consume it before it leaves the furnace. The excess air necessary to do this depends upon the rate of heating and the distance of the burner from the flue. This excess air enters the furnace cold and leaves it heated to the temperature of the escaping flue gases. The furnace described above is commonly held at about 1,400 degrees F. in order to keep the bath at about 840 degrees F. in galvanizing. The distance from the burners to the flues must be short, owing to the nature of the installation. If 50 per cent excess air were used, an absorption loss of about 11 per cent of all the heat liberated would occur.

Again when excess air passes through a reacting zone, the hindrance offered by the non-reacting gases serves to reduce the speed of combustion and to enlarge the zone of combustion. This lowers the reaction intensity or temperature. The gas consumption necessary to overcome the effect of 50 per cent excess air when operating at 1,400 degrees F., in a small furnace must be 22.2 per cent higher in the case of 650 Btu gas, for which the data was recently secured. The reduction of scale formation, due to absence of free oxygen is quickly noticed.

A final item, but not the least from a cost and trouble standpoint, is the removal of necessity for draft, making a stack entirely unnecessary. The complete tightness of the setting and the fact that the products of combustion are swept into the flue holes by the constant formation of a new supply from mixture forced into the furnace under positive pressure, readily makes the matter clear.

TECHNICAL ADVANCES IN FORGING DURING 1919.

(Continued from page 112.)

ence in temperature between axis and periphery and lessen the danger of rupture due to this difference.

A great many engineers and manufacturers ordering forgings are in the habit of specifying physical requirements, chemical analysis and heat treatment, this is entirely wrong, for the reason that no two engineers will agree on the same analysis and heat treatment if they have read different text books. The development of heat treating is going on at such a rapid pace the textbooks are always a little behind. Now the engineer always figures the physical requirements of his work; let him insist on this physical requirement and leave the ways and means of meeting this to the forge man.

The forge men are now making a united effort to have the engineers specify only the physical requirements when ordering, leaving to the metallurgist and forge man the selection of material of proper analysis and the heat treatment to meet the physical requirements. The only exception to this is when an alloy steel is required, the engineers should say what alloy they want.

Freyn, Brassert & Co., Engineers, Chicago, have been awarded contracts for a considerable number of Birkholz-Terbeck gas burners for blast furnace and coke oven gas and Steese Hydro Carbon burners by the Semet-Solvay Company, Steel & Tube Co. of America, Punxsutawney Furnace Company, Algoma Steel Corporation, Wellston Iron Furnace Company, Pittsburgh Crucible Steel Company, Joseph E. Thropp, Everett, Pa.; Heppenstall Forge & Knife Co., Pittsburgh, and Shelton Steel, Iron & Coal Co., Stoke-on-Trent, Eng.; Carnegie Steel Company.

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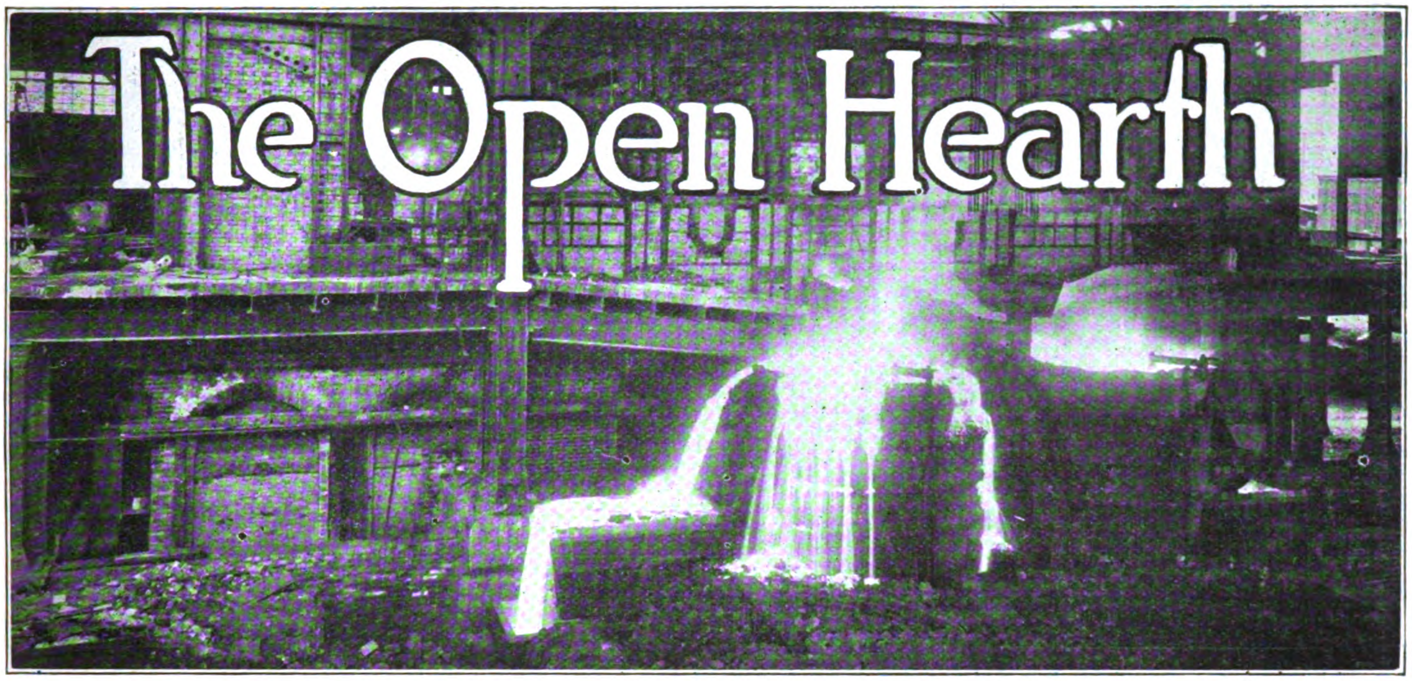


The Open Hearth

William A. Thomas has resigned as president of the Brier Hill Steel Company, Youngstown, O. Mr. Thomas has been president of this company since 1912.

V V

James H. Grose has been elected president of the Brier Hill Steel Company, Youngstown, O. He was previously general superintendent in the Youngstown district for the Carnegie Steel Company.

V V

W. H. Lutz who has been connected with the Reading Iron Company for 35 years, and who was superintendent of one of the company's rolling mills, has resigned.

V V

C. B. Meanor, Jr., has resigned as secretary-treasurer of the Monongahela Iron & Steel Co., Pittsburgh, Pa. His position will be filled by J. H. Creighton.

V V

G. H. Hohl, formerly assistant superintendent of blast furnaces of the Bethlehem, Pa., plant of the Bethlehem Steel Company, has been appointed superintendent of blast furnaces, succeeding C. T. L. Edwards.

V V

Fred P. McLyar is now superintendent of the Newton Steel Company, Newton Falls, O. Mr. McLyar was formerly foreman of the hot mill department at the Guernsey works, American Sheet & Tin Plate Co., Cambridge, O.

V V

J. Ramsey Speer has resigned as president to become chairman of the Pittsburgh Iron & Steel Foundries Co., Pittsburgh, Pa.

V V

Charles McKnight, formerly treasurer of the Pittsburgh Iron & Steel Foundries Co., has been elected to the presidency.

V V

Donald S. Michelson, is now the new general manager of the Worcester Pressed Steel Company, Worcester, Mass.

V V

Fred J. Miller, for a number of years chief editor of the "American Machinist," formerly connected with numerous industrial organizations and at the present a member of the technical advisory committee of the war claims board at Washington, was elected president of the American Society of Mechanical Engineers, at its fortieth annual meeting at New York, succeeding M. E. Cooley, dean of schools of engineering, University of Michigan, Ann Harbor, Mich. Robert H. Fernald, and Edward C. Jones were elected vice presidents. The managers elected were, Elbert C. Fisher, Dexter S. Kimball, and Earl F. Scott.

V V

Warren K. Williams, formerly connected with the American Steel Foundries, Pittsburgh, Pa., and later with the United Engineering & Foundry Co., is now connected with the American Steel & Wire Co. in their wire mill department at Donora, Pa.

V V

Samuel Stoneham, general superintendent of the Union Steel Casting Company, Boston, has resigned. Vice President A. F. S. Blackwood is temporarily filling the position.

V V

Harry Conners is in charge of the operation of the foundry of the Pennsylvania Iron & Steel Products Co., Ellwood City, Pa.

V V

Howard M. Davis, formerly superintendent of the sheet mills of the Gary, Ind., plant of the American Sheet & Tinplate Co., is now general superintendent of the Newport Rolling Mill Company, Newport, Ky.

V V

George S. Vail, sales manager for Arthur G. McKee & Co., Cleveland, recently sailed for England, accompanied by George Garrett, in connection with engineering work for blast furnaces and steel plants.

V V

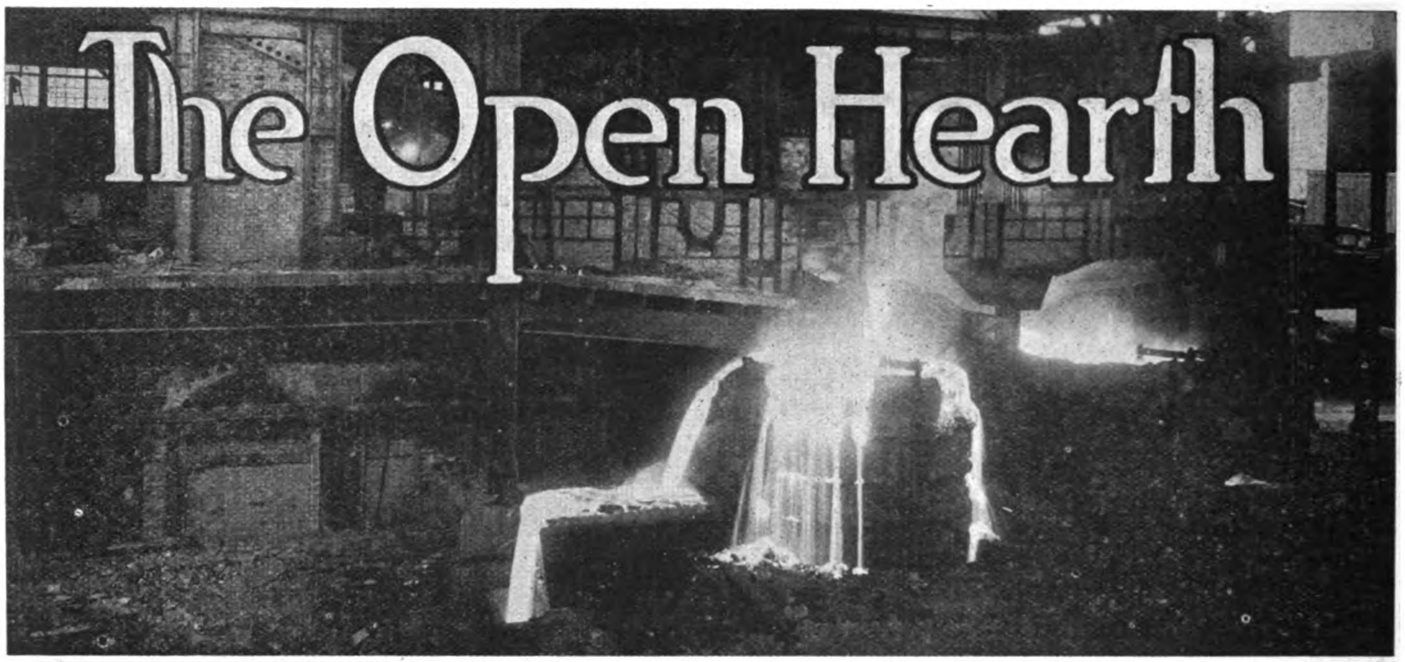
Leopold Tschirky, has resigned as purchasing agent of the Bethlehehm Steel Company. He is now connected with the General Refractories Company, Philadelphia, Pa.

V V

H. H. Harris has been apointed manager of the heat-treating equipment department of the Quigley Furnace Specialties Company, New York.

V V

W. H. Black has resigned as electrical engineer of the Universal Steel Company, Bridgeville, Pa.



The Open Hearth

Lloyd Booth, president Falcon Steel Company, Niles, O., announces the appointment of George E. Harris as sales manager. Mr. Harris will assume his new duties the first of the year. He has been director of sales of the Hawkridge Bros. Company, Boston, and was previously superintendent of the steel department of Peter A. Frasse & Co., Inc., at Buffalo. W. W. Lewis, formerly general superintendent of the old Western Reserve Steel Company, Warren, O., and for a time superintendent of the works after the plant was absorbed by the Brier Hill Steel Company, Youngstown, O., has been named superintendent of the Falcon company. Machinery and equipment are now being installed. The mills were furnished by the United Engineering & Foundry Co., Pittsburgh, electrical equipment by the General Electric Company, and cranes by the Morgan Engineering Company, of Alliance, O. Paul Wick is vice president and general manager of the company.

* * *

Roy Brakeman, who has been chief engineer of the Fairfield works of the American Steel & Wire Co., Fairfield, Ala., has been appointed chief engineer of the Otis Steel Company, Cleveland.

* * *

I. Lamont Hughes, president of Lorain Steel Company, Johnstown, Pa., has undertaken his new duties as district superintendent of the Carnegie Steel Company, in Youngstown, succeeding James H. Grose, resigned.

* * *

E. M. Herr, president Westinghouse Electric & Manufacturing Co., East Pittsburgh, has been appointed chairman of the Ecuador group at the second Pan-American financial conference to be held at Washington, January 12 to 17. Mr. Herr was appointed last year to the same conference, but press of war duties had made it impossible for him to serve, but he expects to serve this year. J. Rogers Flannery of the American Vanadium Company, Pittsburgh, will serve in the group meeting the Bollivan delegates

* * *

Kenneth B. Lewis, Morgan Construction Company, has recently returned from a six months trip through Europe and secured a large amount of export business for the Morgan Construction Company ,Worcester, Mass.

Ray Green is now connected with the Ohio Steel Products Company, Mineral Ridge, O. Mr. Green was formerly secretary to the general superintendent of the Youngstown Sheet & Tube Co.

* * *

R. L. Baldwin, for several years active in the licensing of Heroult electric steel furnaces for the United States Steel Corporation, 71 Broadway, New York, assumes the duties of general sales manager for the Republic Carbon Company, Niagara Falls, N. Y., January 1.

* * *

William P. Starkey, general superintendent Harrisburg Pipe & Pipe Bending Company, Harrisburg, Pa., for the past six years, tendered his resignation, effective December 31.

* * *

T. R. Johns, general manager of the Bethlehem Steel Company's coal properties makes the following announcement with reference to the Penn Mary Coal Company. This company has been reorganized since acquiring the property of the Elkins Coal & Coke Co., at Morgantown, W. Va., this latter purchase represents an acquisition of 220,000,000 tons of by-product coal. The following appointmetns have been made: On the Pennsylvania Division, with headquarters at Heilwood, Indiana County, Pa. Frank Pardoe, recently assistant general manager of the Rochester and Pittsburgh Coal & Iron Co., has been appointed general superintendent, effective January 1, 1920. R. E. Abrams, superintendent; K. M. Quickel, chief engineer. On the West Virginia Division with headquarters at Morgantown, W. Va. Samuel Steinbach, formerly division manager for the Consolidation Coal Company in the Somerset Field, has been appointed general superintendent, effective December 1, 1919. R. E. Pearson, chief engineer. T. R. Johns, general manager, will temporarily reside at Heilwood, Pa., but will establish offices at Bethlehem, Pa., Heilwood, Pa., and Morgantown, W. Va.

* * *

Freyn, Brassert & Co., Engineers, Chicago, announce the appointment of F. L. Collins as power and electrical engineer. Mr. Collins was formerly connected with the Illinois Steel Company, South, and Gary Works, and Universal Portland Cement Company at Buffington as electrical engineer; later joining the Dominion Iron & Steel Co., Sydney, N. S., as chief electrical engineer. Subsequently he was connected with the ordnance department of the United States Steel Corporation at Neville Island, and lately was chief electrical engineer of the Pittsburgh Crucible Steel Company.

INDUSTRIAL RELATIONS

SAFETY MOVEMENT IN STEEL MILLS.

By C. M. Brading and F. A. Wiley.

The accident problem today involves two essential elements—safeguarding and education, in each of which, there is more or less detail. Experience in the past has conclusively proven that safeguarding and education work in any plant, is not a "one-man job;" that satisfactory results can only be secured through the coöperation between the employer and the employe, and this only by means of organization. The employer must be vitally interested in the work, if he expects to educate his men to share the responsibility with him. The men must be given a part to perform in it, if their interest is to be aroused and maintained. The problems must touch them somewhere and they must be brought into direct relationship with the employer. It is only through organization that this is possible.

The form and character of any organization must naturally vary as the work performed varies; hence the work to be done by a safety organization should first be considered before determining what the form of organization should be.

Safeguarding and education comprise the task of safety organization, all of which requires efficient planning, direction and supervision. In safeguarding, there are involved among others, the following essential elements.

1. A study of the hazards incidental to the use of equipment and machinery.
2. Adoption of standards.
3. Inspections for:
    (a) Need of safeguards.
    (b) Installation of safeguards.
    (c) Maintenance of safeguards.
    (d) Use of safeguards.
4. In new construction or replacement, checking in drafting room or purchasing department.

In educational work, there are involved the following essential elements:

1. A study of the hazards incidental to operation.
2. Adoption of safety rules covering safe method of doing works.
3. Instruction of new men as to hazards and rules.
4. Interesting men through safety committees.
5. Posting on bulletin boards, safety bulletins, rules and other information.

The existing working force of every industrial or transportation concern, whether large or small, is adaptable very readily to an accident prevention organization. In any form of organization, the following elements, I believe, are essential:

1. A safety inspector, who should inspect for:
    (a) Need of safeguards.
    (b) Installation of safeguards.
    (c) Maintenance of safeguards.
    (d) Use of safeguards.
    (e) Unsafe practices.
    (f) Plant cleanliness.

He should have charge of all details of safety work, receive all reports, recommendations and suggestions.

2. A central committee of safety, composed of the plant superintendent or his assistant, the safety inspector, and all department heads. This committee should
    (a) Have general charge and supervision of safety work.
    (b) Pass on all matters of controversy.
    (c) Gather all available information.
    (d) Establish standards for safeguards.
    (e) Promulgate rules for safe operation.
    (f) Outline educational campaigns.
3. Workmen's committees in each department, consisting of three or five workmen, appointed and changed periodically. They should
    (a) Make inspections.
    (b) Investigate accidents in their several departments.
    (c) Render reports of accidents and recommendations.
4. Foremen should
    (a) Enforce safety rules adopted.
    (b) Be held responsible for the safety of his men.
    (c) Investigate accidents, reporting causes and make suggestions for method of preventing recurrence.
    (d) Render weekly written reports on forms provided for that purpose.
5. Each workman should be educated and interested in safety matters. This work involves.
    (a) Instruction of new men.
    (b) Familiarizing men with rules.
    (c) Interesting others through bulletin board.
    (d) Discipline.

In smaller plants and factories the development of the workmen's interest in safety and the utilization of his power of safety inspection can doubtless be obtained by a much simpler committee system.

In presenting the suggestions herein outlined, an endeavor has been made to point out certain practicable methods that can be woven permanently into the fabric of any organization without in any way interfering with its ordinary procedure. Whatever methods are employed for making men cautious, it must always be remembered that the spirit and example of the employer interlocked with the direct-contact-influence and activity of the superintendent and foreman, is the vitalizing force in the movement. The superintendent must convince all about him that his desire for safe operation of his plant is as rock-ribbed into his makeup as his intention to maintain its economcal operaton. He should not only have firm convctions about the need of doing work safely, but must find a way to impress them on his department heads and foremen; they in turn must be required to find a way to translate his convictions into the working habits of their men and thus into their very consciousness. Moreover the superintendent or foreman, who himself obeys both the letter and spirit of every safety regulation, will pave the way for the coöperation of all concerned.

The employer's next step lies in the direction of putting all work places and apparatus in good order, maintaining good light and ventilation, and comfortable and sanitary working conditions. Provision for safety goggles, respirators and similar protective devices; also a first aid or dispensary service for prompt treatment of injuries. All these efforts will create an atmosphere of safety and caution that will have a wholesome reaction on the habits of the employes.

The preliminary work cannot be done all at once; in large plants it may require months to complete it. The spreading of the work over a reasonable period of time will even tend to add to its educational value by securing extended attention and interest of the employes during the progress of installation. Questions will arise in the minds of the employes, making them conscious of the employer's efforts for their safety, and awaken an instinct of carefulness within themselves.

These are merely the first steps in sensible safety work; they are necessary and far-reaching, to be sure, but they alone can prevent only a minor proportion of the accidents encountered in industrial work. The larger, and by far, the most telling work must go to the very root of carelessness: namely, the indifference and ignorance which is responsible for most accidents, and for this work, I believe the foreman, the logical man.

From a paper read before Chicago section of the Association of Iron and Steel Electrical Engineers.

NEWS OF THE PLANTS

The Electric Alloy Steel Company has been capitalized at $1,500,000. The incorporators are: James A. Campbell, A. E. Adams, L. J. Campbell, L. A. Manchester and C. D. Hine. L. J. Campbell, formerly vice president of the Youngstown Sheet & Tube Co., will be president of the new concern, his resignation taking effect January 1, 1920. The Electric Alloy Steel Company will manufacture high-grade steels and high-speed tool steels. The equipment of the new concern will comprise electric furnaces, rolling mills and steel hammers. Barton R. Shover, Pittsburgh, Pa., has been retained as consulting engineer for the entire plant, which will be located in the Youngstown district.

The Gulf States Steel Company, Gadsden, Ala., is planning for the construction of a large addition to its plant for increased capacity. The new structure will be equipped as a wire mill, providing an increase in this department of operation by about 30 per cent. Details of construction are now being arranged, and it is proposed to inaugurate active building early in the coming year. The new structure will be equipped to give employment to about 300 men, and is estimated to cost about $200,000.

The Iron Products Corporation, 90 West street, New York, is planning for extensive improvements and additions to its blast furnaces at Chattanooga, Tenn., to cost about $150,000. This company, which is a consolidation of the Essex Foundry and the Central Foundry Companies, of Newark, N. J., has recently acquired the properties of the Chattanooga Iron & Coal Corporation, Chattanooga, Tenn., comprising about 20,000 acres of ore and coal lands, with a modern blast furnace. The company also owns and operates a blast furnace at Holt, Ala., with coal mines, by-product coke ovens, ore properties, and other facilities. The combined annual output of the different furnaces is about 200,000 tons. The company also operates a total of nine foundries in different parts of the country. George A. Harder is president.

The A. O. Smith Corporation, Milwaukee, Wis., manufacturer of steel products for automobile and other use, has commenced the construction of additions to its plant for increased capacity. Enlarged facilities will be provided for the manufacture of automobile frames, and a completely equipped machine shop for steel service. The expansion is estimated to cost about $350,000. W. E. Seymour is vice president and general manager.

The Kasle Iron & Metal Co., 1112-20 Elm street, Toledo, O., is having plans prepared for the construction of a one-story addition to its plant to be equipped as a smelting works. The structure will be 75 x 150 feet, and bids for construction will be asked in about 60 days. The new building, with equipment, is estimated to cost about $40,000. Samuel Kasle heads the company; Edward Thal, 315 Nichols Building, is architect.

The Milliken Brothers Manufacturing Company, Inc., Woolworth Building, New York, with local plant at One Hundred and Thirty-sixth street and East River, has commenced the active production and sale of all-steel buildings, known as Milliken Buildings. The plant has been equipped for greatest facility in all departments of operation, and a galvanizing works is contemplated at a later date. Recent shipments of these buildings include an aggregate of 28 steel frame structures for export account, embracing Colombia, Cuba, San Domingo, Venezuela, and points in the Levant; these structures approximate 41 feet wide by 120 feet and longer in length. The company has taken a contract for the erection of a new steel building for the Lehigh Machine Company, Lehigh, Pa., and for a new forge works for the Frost Gear & Forge Company, Jackson, Mich. Erection is under way for two new buildings for the Boston & Lockport Block Co., Boston, Mass., and for a new industrial building at Alburtus, Pa. The company plans for expansion in its shop facilities to handle all features of structural steel work. C. T. Clark is president; J. E. Jennings, vice president, and Robert Grant, head of the well-known iron and steel concern of this name, is treasurer.

The Van Dorn Iron Works, 2685 East Seventy-ninth street, Cleveland, O., is having plans prepared for the erection of a large addition to its plant at East Seventy-ninth street and Woodlawn avenue, for increased capacity. The new factory will be three-story, brick and steel, 100 x 225 feet, and will be equipped primarily for the manufacture of steel bodies for motor trucks. The new plant, with equipment, is estimated to cost about $250,000. P. D. Van Dorn is president.

The Northwestern Iron Works, Devils Lake, N. D., is considering plans for the construction of a new local iron and steel works. The proposed buildings will include general steel working plant, forge shop, tin shop, foundry, machine shops and other structures. Samuel A. Hann is president.

The Louisiana Steel Company, Shreveport, La., has been organized with a capital of $10,000,000 by officials of the Texas Steel Company, including L. P. Featherstone, Beaumont, Tex., and associates. The new company is planning for the construction of a large steel works in the vicinity of Shreveport, La., and is understood to have secured a site for this plant; it will be equipped for the manufacture of iron and steel products of various kinds. The company has also acquired extensive iron ore property in the eastern part of Texas, and will establish a large iron ore mining plant, to provide raw material for the new works. Details of the plants and installations are now being arranged.

The Edward G. Budd Manufacturing Company, Twenty-fifth street and Hunting Park avenue, Philadelphia, Pa., manufacturers of steel automobile bodies and other steel products, has plans prepared for the construction of a four-story reinforced concrete addition to its plant for increased capacity. The structure will be about 100 x 300 feet, and with machinery and equipment is estimated to cost about $500,000. The company will also build a one-story warehouse for increased facilities in this department. Arrangements have been made to increase the capitalization of the organization from $2,000,000 to $4,251,700 for general expansion.

The Aetna Iron & Steel Co., Gary, Ind., has completed plans and is taking bids for the construction of its proposed new local plant. The company recently acquired property aggregating about 400 acres of land in this section, and the proposed new works will comprise four individual units. These buildings will consist of a sheet mill, 86 x 562 feet; a furnace building 43 x 552 feet; an annealing and galvanizing shop 84 x 625 feet, and a shipbuilding works 30 x 500 feet. The plant will be fully equipped in all departments, and the installation will include in addition to steel mill machinery a number of electric traveling cranes of about 30-ton capacity. The plant will be devoted to the manufacture of steel sheets and other iron and steel products.

The Hydraulic Pressed Steel Company, Cleveland, O., has perfected plans for a reorganization for general expansion. The various subsidiaries of the company will be merged under the name of the Hydraulic Steel Company, with an authorized capitalization of $6,000,000. These subsidiaries include the Cleveland Welding & Manufacturing Co., the Hydraulic Steelcraft Company, and the Canton Sheet Steel Company. The company is planning for extensions in its manufacturing facilities to include the manufacture of steel barrels.

WITH THE EQUIPMENT MANUFACTURERS

OXY-ACETYLENE GENERATING EQUIPMENT.

Necessity, besides being the "mother of invention" is often the cause of radical changes. During the rush for war materials in the winter and summer of 1918, the Morse Dry Dock & Repair Co., of Brooklyn, N. Y., which at that time was purchasing acetylene from an outside concern, was constantly beset by the uncertainty of supply for that particular product. At times it had been necessary to send trucks as far away as Bayonne, N. J., to obtain gasoline gas. This often proved a disadvantage and negotiations were opened with the Davis-Bournonville Company, manufacturers and distributors of oxy-acetylene equipment, and today there is located at the rear of the new Morse heavy marine forge shop an acetylene plant the equal of any similar establishment.

The Morse acetylene generating and compressing plant produces 13,000 cubic feet of gas each week and this is forced under high pressure into the cylinders which are used by the acetylene welding department.

There are two generators, each having a carbide capacity of 300 pounds at a single charge. From the purifier and drier chambers and to the high-powered triple-action compressor, the gas is forced through the charging line until 12 cylinders are charged up to 250 pounds each. An extensive water cooling system is utilized through the compressor jackets and on the charging line.

In addition to overcoming any possible curtailment of its acetylene gas supply, the Morse company has also taken the precaution to safeguard against any possible explosions. To this end, the roof of the building is fitted with a grade and two ventilators especially adapted for ridding the upper part of the room of any gases which may have collected there. The motor switches are of special design to prevent sparking and the carbide is stored in a brick-tight chamber nearby.

While electric welding has been more or less, in general use, in many industries for some years, its application to shipbuilding has also progressed wonderfully at the Morse company's Brooklyn yards. This system of binding fractured castings, uniting neighboring parts of steel and otherwise promoting fabrication, or hastening repairs, was used by the Morse company during the war on such boats as the Von Steuben, George Washington, Huron, Kroonland and others.

On the Von Steuben 30 tube sheets in the main boiler were welded. The base of the turning gear for the main engine of the General Gorgas was welded in 24 hours. At the completion of the work, it was perfect in alignment and turned the engine over with ease.

In repair work, which will form a considerable part of the problem of maintaining a merchant marine, electric welding has been demonstrated to have its peculiar value.

By establishing and perfecting its acetylene gas and electric welding plant, the Morse company has placed itself foremost in the maritime burning and welding field. The company is therefore in a position to do work of the kind on large and small jobs and with a minimum loss of time.

SURFACE COMBUSTION OVEN FURNACE.

The Surface Combustion Company, 366-368 Girard avenue, Bronx, N. Y., has placed on the market an oven furnace known as type A-25. This furnace is equipped with a special door-lifting mechanism that has recently been developed, the design of which was worked out after a careful study of practical requirements. A link motion is employed for this purpose, which not only allows the door to move up and down vertically, but effectually prevents it from making any other movement. Simplicity and compactness of construction are claimed for this mechanism, and it is stated that a furnace door equipped in this way tends to remain either in the open or closed position without relying on friction to hold it there.

ROCKWELL HARDNESS TESTER.

For use in testing the hardness of all kinds of metals by the Brinell method, S. P. Rockwell, 122 Dickerson street, Syracuse, N. Y., is now making a testing machine. It is claimed that this machine gives very accurate results and that it is adapted for testing both curved or flat surfaces and either thin or thick sections. It operates rapidly, and may be carried around without trouble. Another important feature is that it does not excessively mark or destroy the work on which a test is made, and that the machine is adapted for testing the hardness of all metals ranging from lead to hardened steel. The machine consists of a sturdy hollow cast frame and a plunger, which holds the testing point at one end and abuts against a delicate measuring device at the other end. A series of levers with knife-edges connects this plunger with a weight, and by shifting the position of the weight, more or less force may be applied to the testing point to suit conditions.

A vertical moveable chuck holds the piece on which a hardness test is to be made, this chuck being actuated by a handwheel. The piece to be tested is placed in this chuck and raised by the handwheel until it comes into contact with the testing point. At this moment, the initial pressure is applied through the point to the work, in order to cause the point to break through the light scale, decarbonization, etc., so that it may more clearly test the condition of the true metal beneath. Upward movement of the work is continued until the plunger has actuated the measuring device to a degree sufficient for testing; then the final weight is applied by a hand-lever, and the hardness is read direct by the difference of the testing point's position as indicated by a measuring device. The elasticity of the metal may also be determined by the test point's difference of position from final pressure to initial pressure.

With an equipment of this kind, an average operator can readily make six tests per minute. The greatest value of this machine for shop use is as a comparative tester. For such work, hardness limits are established by the Brinell, scleroscope, file, or working tests, and the Rockewell hardness tester is then set for the particular class of work on which it is to be used, and its limits are established. If so desired, the indicating dial can be calibrated in Brinell, scleroscope, file, or working tests, and the Rockwell hard-trolytic iron as zero per cent soft. Such dials are available as a special equipment. All work has allowable variations in hardness, and for fast operation of this instrument an extra pointer may be provided. The angular difference in the position of the two pointers represents the allowable hardness variation; and if in operation the two pointers straddle the graduation indicating mean hardness, the work comes within the specified limits. Failure to straddle the mean graduation indicates that the work is too hard if the pointers are on one side, or too soft if they are at the opposite side.

In view of the increasing need for readily applicable means for hardness testing, convenient and simple to operate, the machine described constitutes an interesting development which will, in addition to other means already available, make it possible to control the quality of manufactured articles, especially those subjected to various heat-treatments.

Trade Publications

The W. S. Rockwell Company have recently issued a new bulletin No. 200. This bulletin illustrates and describes in detail a new and novel type of side-opening heat-treatment furnace. It was developed to heat-treat material varying widely in shape and size, which the ordinary furnace cannot do.

This furnace is 36 feet wide. Stock approximately this length may be placed in the furnace for heat-treatment, or the furnace may be partitioned off into individual chambers 5 feet 9 inches wide or multiples thereof. Thus, while one chamber is heating stock say five feet long, the other part of the furnace could be heating stock either much longer than five feet or smaller. This furnace has proved so advantageous in operation that it is now being widened to provide a working chamber 105 feet wide in the clear, the length remaining the same. This increased width will provide facilities to anneal and heat-treat the largest shafts and similar pieces handled in this forge shop.

The doors of the furnace can be raised or lowered independently of one another. They are operated by compressed air and counterweights. They are dovetailed and form guides within themselves that prevent the escape of hot gases. The roof of the furnace is constructed of flat tiles, avoiding the thrust caused by the ordinary arch construction.

The furnace is underfired, assuring the most uniform heat-treatment. It is provided with preheaters over the vents. The air in these preheaters thus returns through the burners the greater portion of the heat in the spent gases that would otherwise be lost. The fuel consumption in this furnace is extremely low, due to the efficient application of the heat and the utilization of the waste heat ordinarily lost. Oil or gas may be used as fuel. Expansion of the brickwork, or of the furnace as a whole, is taken up by heavy springs at the side of the furnace. The overhead trusswork has been so divided as to prevent any distortion due to the heat in the furnace.

Trade Notes

The American Metallurgical Corporation, Franklin Trust Building, Philadelphia, Pa., announce the receipt of a contract amounting to $111,000, for the development of special machines for the Adwear Process Sole Leather Machine Company, Philadelphia. The machines are to be fitted with special electric cartridge units of the General Electric type for the melting of the wax and the heating of the machine parts used in connection with the leather processing. Each machine will also be equipped with individual motor drive.

W. R. Phibbs, assistant general manager of the Steel & Tube Co. of America, Mayville, Wis., has resigned to become Eastern representative of the James A. Brady Foundry Company, who manufacture the Harrington Forced Draft Convertible Stoker.

International Oxygen Company with main offices at Newark, N. J., is establishing a new branch plant at Toledo, O., to furnish oxygen and hydrogen for all purposes to the numerous manufacturers and industries in that busy industrial section using either one or both of these gases in their processes. The capacity of the plant will be 3,000,000 cubic feet of gas per month, the purity of which will be 99.5 per cent and higher. Over 200 I. O. C. system oxygen hydrogen generating plants are now in operation, not only in the United States but in practically every foreign country as well and the Toledo plant when completed will be the finest of its kind in existence.

A new bulletin entitled "Lane Electric Cranes," has just been issued by N. B. Payne & Co., 25 Church astreet, New York City, sole agents for Lane Electric Cranes, manufactured in Montpelier, Vt., by the Lane Manufacturing Company. The bulletin fully illustrates and describes several styles of cranes in which steel girders or heavy timbers of long leaf yellow pine are used. A record of 30 years is claimed for this crane—minimum power and repair cost—great overload capacity—high return value on capital investment, and the cranes can be operated by inexperienced labor. The bulletin contains a complete set of specifications and a very long list of satisfied users. A questionnaire is inserted in the bulletin for the use of the prospective purchaser on which he can quickly write all information needed by the manufacturers.

The Richardson-Phenix Company have opened a Birmingham office in charge of James D. Scruggs.

Prompted by the need of and demand for a better understanding on the part of the public generally, of the fundamental soundness of the American constitutional government and the fallacious, and in some cases, vicious attacks upon it, several influential business men of Milwaukee have formed the American Constitutional league. The league is nonsectarian and non-racial in membership and purpose. Its activities will be confined solely to Americanization work, which will embrace al forms of education and publicity in favor of Americanism and in opposition to all radical doctrines which have for their purpose the overthrow of our existing form of representative government and our present social and industrial order. Frank R. Bacon, president of the Cutler-Hammer Manufacturing Company of Milwaukee, Wis., has been elected chairman of this new organization.

The American Metallurgical Corporation, Franklin Trust Building, Philadelphia, announce the closing of a contract with the York Hardware & Brass Works, Inc., for the installation of a 1,000 pound revolving electric furnace of the Weeks type for the melting of brass and copper alloys.

The word "American" has been dropped from the name of American International Steel Corporation, which will hereafter be known as International Steel Corporation. It was found that the name of the steel corporation, which is one of the group of companies operating under American International Corporation ownership, was sometimes confused with that of the parent corporation, and the change was desirable for this reason, as well as for the convenience of the shorter name.

The success achieved by the steel subsidiary in the short period since its organization, little more than two years ago, is remarkable even when allowance is made for the prestige naturally accruing to a subsidiary of the great American International Corporation whose entire resources are employed in the development of foreign trade. International Steel Corporation's business has mounted steadily, despite the unfavorable conditions which have tended to restrict the industry; and the year is closing with millions of dollars worth of unfilled orders on the books.

Its original offices with the parent corporation at 120 Broadway, have been outgrown and it has leased the entire third floor of the Emigrant Industrial Savings Bank Building at 51 Chambers street, where it will occupy new quarters about February 1. Allied Machinery Company of America, another subsidiary, also has its offices in the same building.

Among other companies in the A. I. C. group are G. Amsinck & Co.; Carter Macy & Co.; Rosin and Turpentine Export Company, and American Balsa Company. American International Corporation also has substantial investment interests in International Mercantile Marine, United States Rubber Company, Pacific Mail Steamship Company, United Fruit Company, and New York Shipbuilding Company. One of its notable achievements is the construction and operation of the Hog Island shipyards. It also has a number of large projects under way in foreign countries. The directorate includes many of the best known financial and industrial leaders in this country. Charles A. Stone of Stone & Webster is president, and Frank A. Vanderlip is chairman of the board.

The directors of International Steel Corporation are all identified with the parent corporation. The president is C. A. Richards, whose services were invaluable to the War Trade Board during the war. Morris Metcalf is executive vice president, and Albert C. Mann is vice president in charge of purchasing and traffic.

The Blast Furnace and Steel Plant

Pittsburgh, January, 1920.

Modern Steel Mill Equipment

THE rapidly increasing use of Hyatt Roller Bearings in modern steel mill equipment of all kinds merits your careful investigation.

There are now in operation in well known steel mills 29 Hyatt Roller Bearing equipped mill tables, 2,057 Hyatt equipped steel mill cars and 32,989 Hyatt equipped plate castors. SEE PAGES 4 and 5.

The new Hyatt equipped Wellman-Seaver-Morgan dock cranes at Boston exceeded Government specifications. SEE PAGES [illegible] 43.

Hyatt Roller Bearing equipment will give you the same steady dependable service that these other steel mills receive.

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